SOLAR ACTIVITY:

A DOMINANT FACTOR IN CLIMATE DYNAMICS

by

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1. “Solar Constant” Variations in the 11-Year Sunspot Cycle and Climatic Effects

Atmospheric circulation, the cause of weather, is driven by the sun’s energy. Climate is the integral of weather over periods of more than a year. This integral also depends on the flux of solar energy. The same applies to variations in the energy flux caused by the sun’s varying activity. Satellite data show that the “solar constant” ***S*** is variable. The solar irradiance decreased from the sunspot maximum 1979 to the minimum 1986, increased again on the way to the next maximum in the 11-year sunspot cycle, and decreased anew in the descending phase. This came as a surprise as it is plausible that the dark sunspots with their strong magnetic fields impede the free flux of energy from the sun’s interior to the outside. Yet P. V. Foukal and J. Lean **[22]** have shown that bright faculae in the vicinity of sunspots increase even more than sunspots when the activity grows stronger, so that an irradiance surplus is established.

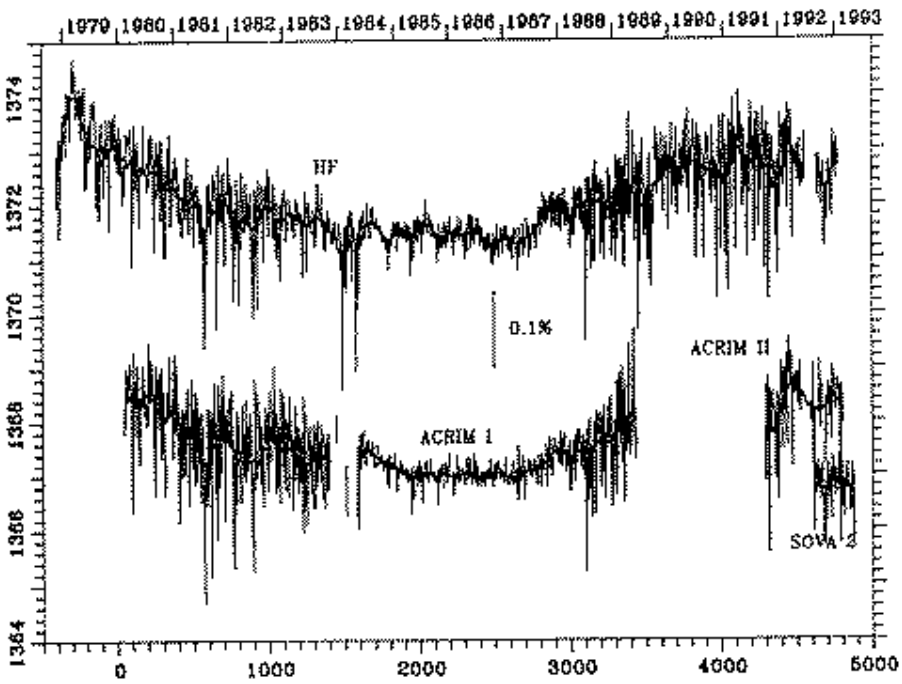

Figure 1

IPCC scientists hold that the corresponding variation in the solar constant **(Delta *S*)** is smaller than 0.1% and has no impact on climate that could count in comparison with the greenhouse effect **[94]**. Yet they fail to appreciate that quotes of 0.1% in the literature refer to the absolute amplitude of the sinusoidal variation in the solar constant, not the whole change from minimum to maximum, or from maximum to minimum **[25, 32, 39]**. Figure 1 after C. Fröhlich **[25]** shows this distinctly. The data at the top of the figure, designated by **`HF'**, represent NIMBUS-7 measurements. The smoothed curve shows the 81-day running average related to the interval of three solar rotations of 27days. The horizontal axis indicates the investigated period, above in years, below in days since the first day of 1980. The vertical axis measures the solar constant ***S*** in W/m^2. The scale in the middle of Figure 1 indicates the range of 0.1%. When this scale is taken to measure the variation in the smoothed curve from the sunspot maximum 1979 to the minimum in 1986, the result is **Delta *S*** approximately equal to **-0.22%**. IPCC scientists cannot object to this higher value on the grounds that it is not a common practice to assess the total variation in such a way. They proceed equally by relating the rise in global temperature to the minimum at the end of the 19th century and not to the long-term temperature mean.

According to satellite measurements, the mean value of the solar constant is ***S*** = **1367 W/m²**. 0.22% of this amount of energy equals **3 W/m²** . This result may also be read from Figure 1. The maximum of the smoothed curve is at 1374.2 W/m² and the minimum at 1371.2 W/m² . The variation of 0.22% does not affect climate in its entirety. The solar constant defines the amount of energy which just reaches the outside of the earth's atmosphere. **30%** of this energy is not absorbed by the atmosphere, but reflected. Furthermore, it has to be taken into account that the irradiated sectional area of the earth constitutes only a quarter of the surface to which this thermal energy has to be distributed. So there is only **239 W/m²** available to heat the atmosphere. Consequently, the variation of 3 W/m² has only a climate effect of **0.53 W/m²** . How this affects global temperature depends on the general circulation model used to assess the climate sensitivity. C. Fröhlich **[25]** proceeds from a value between 0.3° and 1.4° C / W/m² . When we choose the mean value 0.85° C / W/m² to avoid an overestimation, the climate effect of 0.53 W/m² yields a temperature effect of **0.45° C**. The chosen mean value lies within the range given in the literature **[19, 31, 33, 82, 87, 89, 115]**. Even if a four times longer smoothing interval is chosen as in Figure 1, the variation of the solar constant reaches 2.2 W/m² **[74]** with a temperature effect of **0.33° C.**

Variations in global temperature of 0.45° or 0.33° C in the course of seven years cannot be considered negligible. This all the more so as the observed rise of temperature during the last hundred years amounts to merely **0.4° C**. From the value 0.5° C, quoted in the literature, 0.1° C has to be subtracted because it is due to urban warming that causes a spurious rise in global temperature **[39]**. Observed climate data, which follow the rhythm of the 11-year sunspot cycle, indicate that the effect of irradiance variations on the atmosphere is enhanced by positive feed-back processes or stochastic resonance. This form of resonance involves the cooperative interplay of random and periodic stimuli. Noise can improve the response to small periodic or quasiperiodic signals so that the small input is able to entrain large scale fluctuations **[80, 116]**. This effect is strongest in nonlinear systems with a high level of noise.

The atmosphere meets these conditions. K. Labitzke and H. van Loon **[51]** have discovered a statistically significant connection between temperature-dependent 30-hP heights in the stratosphere and extrema in the 11-year sunspot cycle, which involves the troposphere and is strongest in special geographical regions. It is an indication of feed-back or resonance amplification that the temperature difference in the stratosphere between minimum and maximum of the 11-year cycle reaches 1.8° C and in the troposphere still 0.9° C **[50]**. In the Subtropic troposphere this difference even amounts to 2° C **[70]**. Northern and Southern Hemisphere show such sunspot related temperature patterns in a mirror-symmetric way. The geographic distribution of the temperature effect corroborates the hypothesis that a modulation of Hadley cell circulation is involved **[95]**. Experiments with models have shown that winds in the lower stratosphere can have an impact on circulation in the troposphere **[84]**. Strong temperature variations following the course of the 11-year sunspot cycle were not only observed in recent decades. According to M. Stuiver, P. M. Grootes, and T. F. Braziunas **[109]** the GISP delta ^{18}O climate record shows a close correlation with the 11-year sunspot cycle for hundreds of years. This data point to a regional temperature variation of **2.6° C** following the sunspot rhythm.

2. Gleissberg Cycle of Solar Activity and Climate Change

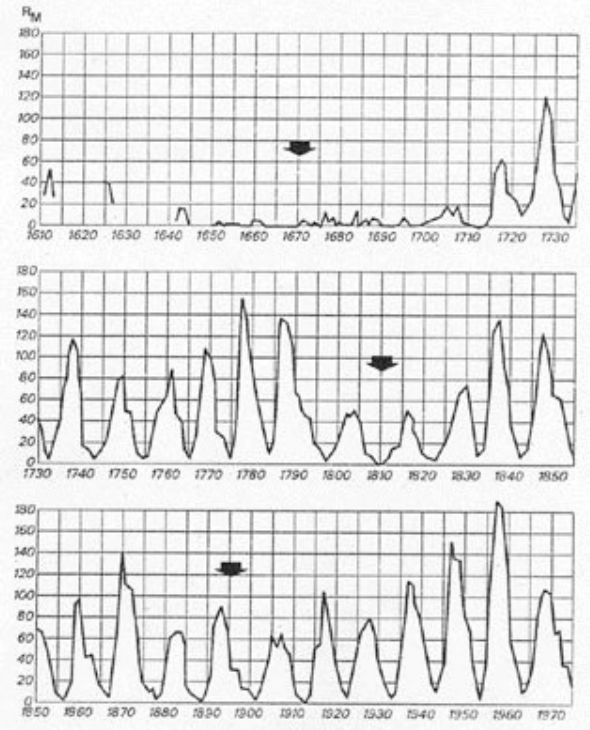

Figure 2

As to climate, seven years is a rather short interval. A climatic effect caused by total irradiance variations becomes more effective when its impact lasts longer. The Milankovitch theory in its modern form shows that a change of **0.1%** effective during a very long interval can release a real ice-age **[49]**. So it may be expected that the 90-year Gleissberg cycle of sunspot activity, which modulates the intensity of the 11-year cycle, possesses a considerable potential to accumulate an effective surplus of irradiance, or to induce a steadily decreasing level of radiant flux density, particularly since the Gleissberg cycle can reach a length of 120 years **[58]**. **Figure 2** after J. A. Eddy **[17]** shows the strong intensity variations in the 11-year sunspot cycle. When we connect the peaks by an enveloping curve, minima in the Gleissberg cycle emerge around the years **1670** (Maunder minimum), **1810**, and **1895**. They are marked by black arrows. Each of these secular sunspot minima coincided with cool climate in the Northern Hemisphere. The deeper the level of solar activity fell, the deeper sank the temperatures.

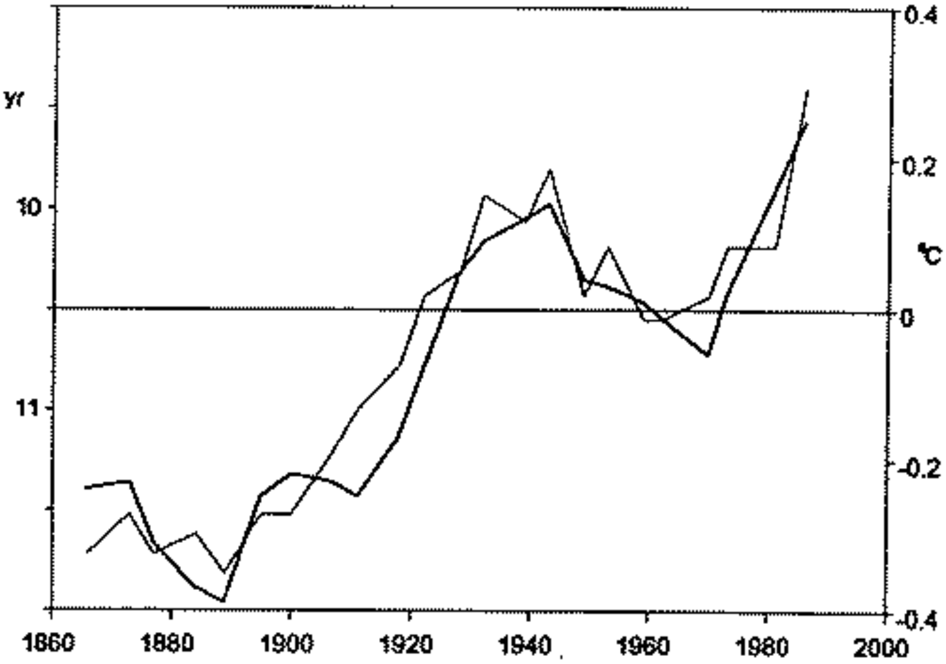

Figure 3

In **Figure 3** after E. Friis-Christensen and K. Lassen **[24]** this connection becomes quite evident. The thick curve shows the Northern Hemisphere surface temperature (right scale), while the thin line represents the length of the 11-year sunspot cycle (left scale) covering the years 1865 to 1985. Occasionally, this impressive synchronism is objected to on the grounds that the length of the cycle should be of no import, as only the intensity of sunspot activity would count in a potential climate effect. Yet the **length** of the 11-year cycle is a measure of its intensity. Short cycles generate high sunspot maxima, wheras long cycles are characterized by weaker sunspot activity. Friis-Christensen and Lassen have shown that the close correlation extends back to the 16th century **[68]**. C. J. Butler **[10]** corroborated these results when he investigated English temperature data since 1796. Together with the results elaborated by Labitzke and van Loon this is an indication that the solar influence on climate is considerably stronger than IPCC scientists assume.

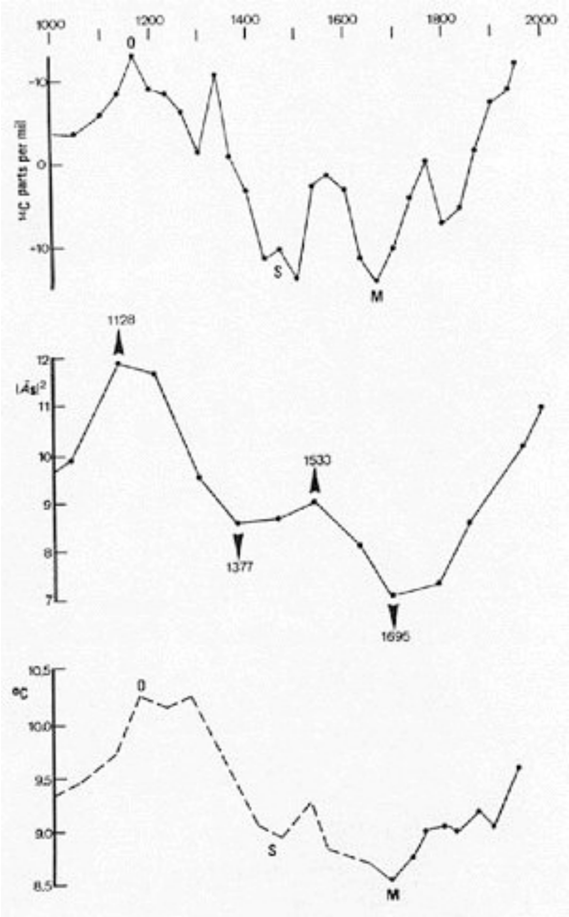

Figure 4

Those scientists who spread anxiety in the eighties by predicting climate catastrophees cannot plead that at this time there were not any publications pointing to a relation between solar activity and climate that had to be taken seriously. The relationship in Figure 4 was presented at the international climate symposium ***"Weather and Climate Responses to Solar Variations"*** in Boulder, Colorado, as early as 1982 **[55]**. The plot shows a temperature time series after H. H. Lamb and C. D. Schönwiese at the bottom, radiocarbon data after J. E. Eddy **[16]** — proxy data reflecting solar activity — covering the interval 1000 to 1950 at the top, and in the middle data I had derived from a semiquantitative model of cyclic solar activity. S and M mark the Spoerer minimum and the Maunder minimum of sunspot activity, while O points to the medieval climate optimum which coincided with very strong solar activity. The synchronism of these three time series, covering 950 years, extends the connection elaborated by Friis-Christensen and Lassen 550 years farther back into the past and opens a possibility of long-range forecasts, as the data in the second curve are based on calculations that can be extended far into the future. On this basis, I forecasted, in 1982, that we should expect declining temperatures after 1990 and probably a new Little Ice Age around 2030. In further papers I specified this prediction **[58, 59, 63]**. I also expected considerably weaker sunspot activity after 1990. The slowly ascending new sunspot cycle, which started in May 1996, seems to follow the predicted trend.

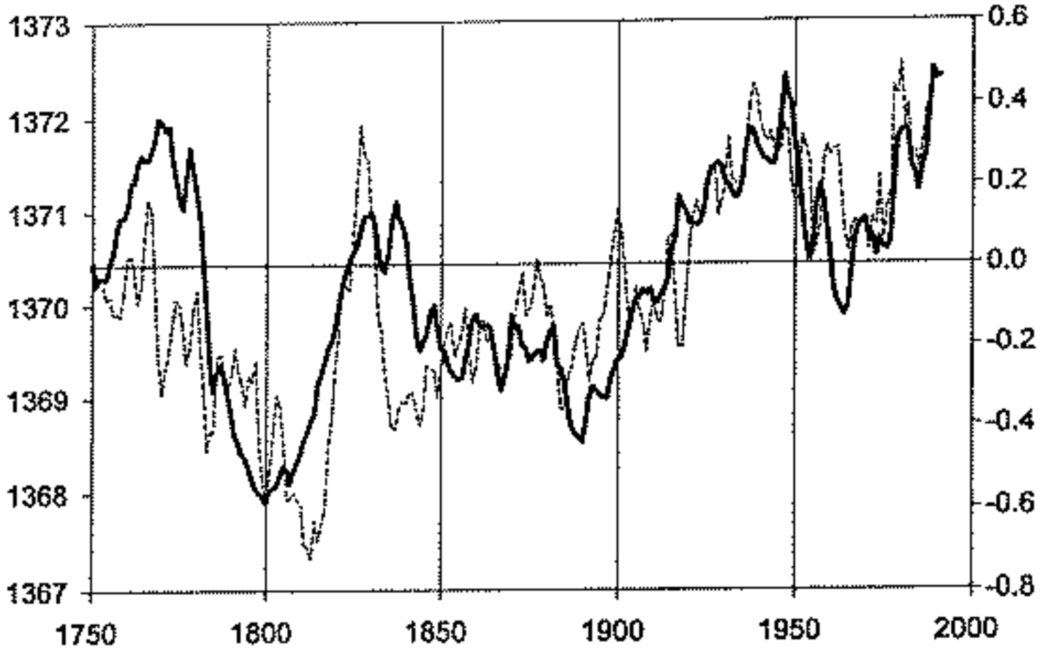

Figure 5

When satellite observations had established that the solar constant is variable, phenomenological regression models were developed which assess the variations in irradiance in past decades and centuries. The model developed by D. V. Hoyt and K. H. Schatten [39], shown in Figure 5, is based on proxy data related to secular changes in the convective energy transport or the convective velocities in the sun. They include the solar cycle length, the equatorial solar rotation rate, and sunspot structure. This solar-irradiance model has only two parameters: the amplitude of variations of the 11-year cycle and the Gleissberg cycle. The thick curve in Figure 5 shows the output of the model. The corresponding vertical axis on the left measures the irradiance in W/m^2. The dashed curve represents the smoothed annual mean Northern Hemisphere temperature variations (right scale) for 1700 – 1879 from B. S. Groveman and H. E. Landsberg [28], and for 1880 to the present from J. E. Hansen and S. Lebedeff [30]. The two curves show a close correlation that points to a strong link between solar activity and climate.

As direct measurements of **Delta *S*** are not available before 1978, it is important that observations of the surface magnetism of solar type stars have yielded variations in irradiance up to 0.6% [84]. Variations of this order in the sun's activity could explain climate features like the "Little Ice Age", especially if it is assumed that the general magnetic network, which covers the photospheric surface even in a sunspot minimum, vanishes during activity lulls of the Maunder minimum type. Every fourth of the observed stars is in a state comparable to the Maunder minimum of the sun [84]. One star — HD 3651 — was even observed just in transition between the cyclic and the Maunder minimum phase. It showed periodic behaviour for about 12 years and then stopped fluctuating as its surface activity dropped to very low levels [84]. This indicates that the sun has a much stronger potential of irradiance variation than assumed. The satellite observations since 1978 cover only a small part of the sun's range of variability. S. Baliunas and W. Soon [2] have shown in addition that short star cycles produce stronger magnetic activy and irradiance than long cycles. This confirms the results published by Gleissberg, FriisChristensen and Lassen.

When measuring the equivalent width of the high excitation photospheric line of C 5380 Å in the solar irradiance spectrum since 1978, W. Livingston discovered that it increased in strength by 0.081 mÅ within 12 years. This implies a temperature increase of 4.6° K, an order of magnitude greater than the variation observed by satellites. Since change in the intensity of absorption lines points to change in the irradiance, D. V. Hoyt and K. H. Schatten [39] assume that there are components of varying irradiance beyond sunspots, faculae, and the magnetic network which are not yet known. A candidate could be those recently discovered huge streams of electronically charged plasma flowing beneath the surface of the sun, which ring the solar poles at about 75° latitude and resemble jet streams in the earth's atmosphere. There is also plasma flow similar to the earth's trade winds [104]. As these plasma streams move about 10% faster than their surroundings, the resulting shear induces concentrations in the magnetic fields "frozen" in the plasma which lead to stronger magnetic activity. It is to be expected that research into these features will result in a new index and a better explanation of solar activity. The steady increase in the intensity of the line C 5380 Å over 12 years, observed by Livingston, is independent of the 11-year cycle. It seems to point to a longer cycle of solar activity. Is this the Gleissberg cycle, or a new yet unknown cycle?

3. Variations in the Sun’s Ultraviolet Radiation and Climate Models

Change in the ultraviolet radiation of the sun is much greater than in the range of visible radiation. The ultraviolet range of the spectrum lies between 100 Å and 3800 Å. Wavelengths below 1500 Å are called extreme ultraviolet (EUV). The variation in radiation between extrema of the 11-year sunspot cycle reaches 35% in the EUV- range [119], 20% at 1500 Å [21], and 7% around 2500 Å [34,97]. At wavelengths above 2500 Å, the variation reaches still 2% [21]. At the time of energetic solar eruptions, the UV-radiation increases by 16%. At a sunspot maximum the EUV-radiation raises the temperature in the Ionosphere by 300% in relation to the minimum [21]. Yet most important is that the UV-radiation below 2900 Å is completely absorbed by ozone in the stratosphere. The resultant rise in temperature is augmented by positive feed-back, as the UV-radiation also generates new ozone. Satellite observations show that the ozone content grows by 2% from sunspot minimum to maximum [113]. D. Rind and J. Overpeck are working on a model which explains how the rising temperature in the stratosphere influences the circulation in the troposphere. J. D. Haigh [29] has already assessed this effect in quantitative terms and shows that temperature in the Subtropics and North Atlantic storm tracks are especially affected.

Variations in radiation are not the the sun’s only way to influence climate. Between energetic solar eruptions and galactic cosmic radiation modulated by the solar wind on the one hand and electric parameters of the atmosphere on the other, exist couplings, the strength of which varies by 10% in the course of days, years, and even decades [113]. The most important change is to be found in the downward air-earth current density, which flows between the ionosphere and the surface. R. Markson and M. Muir [71] have shown how this affects the thunderstorm activity, while B. A. Tinsley [113] assumes that electrically induced changes in the microphysics of clouds (electrofreezing) enhance ice nucleation and formation of clouds. These approaches have the advantage to be independent of dynamic coupling between different layers of the atmosphere, since these variations affect the whole atmosphere. Therefore, IPCC scientists who allege that there are not any physical explanations of a solar impact on climate change must be unaware of the relevant literature.

4. Cosmic Radiation, Solar Wind, and Global Cloud Coverage

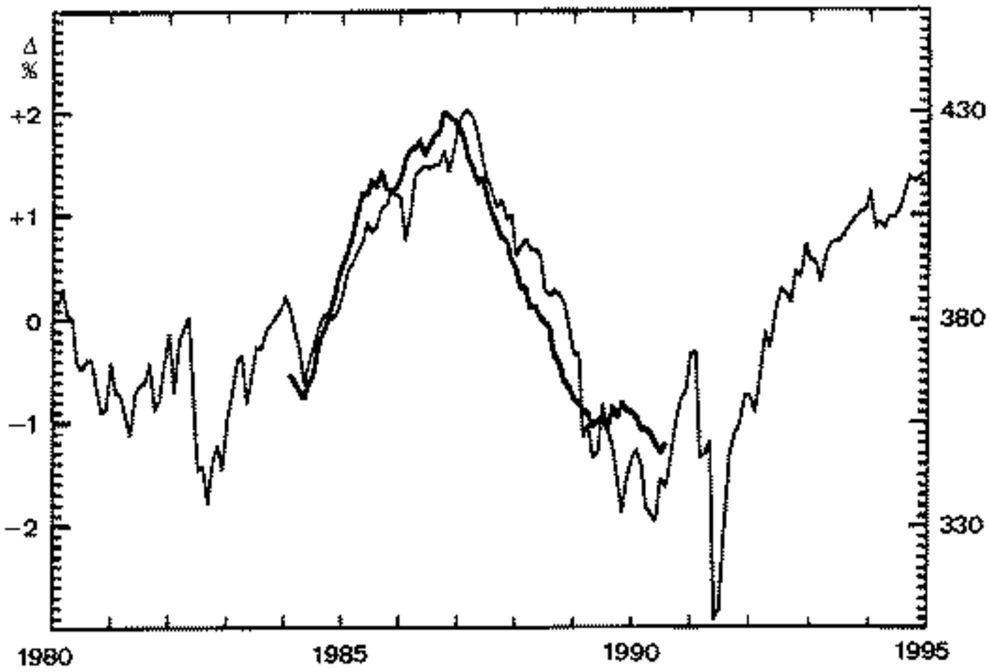

Figure 6

The most convincing argument yet, supporting a strong impact of the sun’s activity on climate change, is a direct connection between cloud coverage and cosmic rays, discovered by H. Svensmark and E. Friis-Christensen [111] in 1996. It is shown in [Figure 6](). Clouds have a hundred times stronger effect on weather and climate than carbon dioxide in the atmosphere. Even if the atmosphere’s CO_2 content doubled, its effect would be cancelled out if the cloud cover expanded by **1%**, as shown by H. E. Landsberg [53]. Svensmark’s and Friis-Christensen’s result is therefore of great importance. The thin curve in Figure 6 presents the

monthly mean counting rates of neutrons measured by the ground-based monitor in Climax, Colorado (right scale). This is an indirect measure of the strength of galactic and solar cosmic rays. The thick curve plots the 12-month running average of the global cloud cover expressed as change in percent (left scale). It is based on homogeneous observations made by geostationary satellites over the oceans. The two curves show a close correlation. The correlation coefficient is
r = 0.95.

Short-range variations in the intensity of cosmic rays, caused by energetic solar eruptions, have the same effect, though shorter. The plot shows that strong cosmic rays go along with a larger cloud cover, whereas weak cosmic rays shrink the cloud cover. The global cloud coverage diminished from its peak at the end of 1986 to its bottom in the middle of 1990 by more than **3%**. According to observations by V. Ramanathan, B. R. Barkstrom, and E. F. Harrison **[91]**, clouds have a net cooling effect of **-17 W/m^2** . Svensmark and Friis-Christensen **[111]** conclude from the diminution of this cooling effect between 1986 and 1990 that the solar irradiance has increased by about **1.5 W/m^2** within these three and a half years. A change of this order is quite remarkable, since the total radiative forcing by carbon dioxide accumulated since 1750 has been estimated by the IPCC not to go beyond 1.5 W/m^2 . This means that cosmic rays, strongly modulated by solar activity, achieve an effect within three and a half years for which the accumulation of carbon dioxide in the atmosphere needs centuries. This shows clearly to what extent the greenhouse effect has been overestimated in comparison with the solar contribution to climate change, which turns out to be the most important factor.

There is also a physical explanation of the effect: the secondary ions produced by the cosmic rays serve as condensation nuclei with hygroscopic properties that enhance the formation of clouds **[4, 15, 23]**. Meanwhile, H. Svensmark **[112]** has extended his investigation that now covers the interval 1980 to 1996. As before, the correlation between cloud cover and cosmic rays is very close. Indirect measurements of the intensity of cosmic rays, which register myons instead of neutrons, go back to 1937. When H. Svensmark **[112]** compared these data with global temperature in the Northern Hemisphere, he again found a strong correlation which indicates that the connection between cosmic rays, cloud cover, and global temperature is real.

The primary cause of the solar modulation of cosmic rays is not the level of sunspot activity, but **the varying strength of the solar wind**. This supersonic outflow of plasma originates in the very hot corona of the sun and carries ionized particles and magnetic field lines from the sun. While it is expanding towards the boundary of the solar system, cosmic ray particles interacting with it lose energy. When the solar wind blows heavily, cosmic rays are weak, and when the solar wind is in a lull, cosmic rays become strong. The highest velocities in the solar wind are caused by energetic solar eruptions and coronal holes. Strong eruptions (flares and eruptive prominences) avoid sunspot maxima and even occur close to sunspot minima. So sunspots are not a good indicator of solar wind strength **[65]**. As cosmic rays, which have such a strong impact on cloud cover, are strongly modulated by eruptional features of the sun's activity, the solar contribution to climate change can no longer be considered negligible. This is all the more so as the already described changes in irradiance have an additional effect.

D. Rind and J. Overpeck **[93]** have shown that at least half of the rise in temperature since the end of the Little Ice Age can be attributed to the parallel rise in the sun's irradiance. D. Hoyt and K. H. Schatten **[39]** judge their elaborate results as follows: ***"From the record, we believe the sun plays a major role in natural secular climatic changes on time scales of decades to centuries."***. E. S. Posmentier, W. H. Soon, and S. L. Baliunas **[88, 107]** eventually derive from a model based on the same solar factors as in the Hoyt-Schatten-model that **78% of the rise in temperature between 1885 and 1987 can be explained by the sun's varying irradiance.** An additional statistical experiment corroborates this result, though it omits the Svensmark effect and other solar-terrestrial relationships which are independent from irradiance. There is not much room left for the anthropogenic greenhouse effect. H. N. Priem **[90]** aptly remarks:

> ***"Recent studies show that solar variability rather than changing CO pressure is an important, probably the dominant climate forcing factor ... The current and anticipated fleet of spacecraft devoted to the study of solar and solar-terrestrial physics will therefore pobably prove to have more bearing on the understanding and forecasting of climate change than the orchestrated assessments by politically motivated international panels biased towards global warming exclusively by the enhanced greenhouse effect."***

The discovery by Svensmark and Friis-Christensen highlights the IPCC objection (that exogenic factors are energetically too weak to have an impact on global temperature), as pointing in the wrong direction. Primary cosmic rays, which regulate cloud coverage, inject a total energy into the atmosphere equal to the intensity of starlight in the night skies **[23]**. J. G. Roederer **[95]** comes closer to reality with his remark:

> ***"The energy argument, however, is not valid for highly nonlinear, complex systems such as the coupled atmosphere-ocean-cryosphere-biosphere. It is well known that complex systems can behave chaotically, i.e. follow very different paths after the smallest change in initial or boundary conditions, or in response to the smallest perturbation. In a highly nonlinear system with large reservoirs of latent energy such as the atmosphere-ocean-biosphere, global redistributions of energy can be triggered by very small inputs, a process that depends far more on their spatial and temporal pattern than on their magnitude."***

5. Failure of Climate Predictions by IPCC Scientists

Precise forecasts that prove correct are a sharp criterion for efficient science. The protagonists of global warming remain empty-handed in this respect in spite of great material and personal expense. In the eighties S. Schneider from the National Center for Atmospheric Research in Boulder, Colorado, predicted in his book ***"Global Warming"*** a huge jump in temperature, polar ice melting away, seas surging across the land, famine on an epidemic scale, and ecosystem collapse. Today this is no longer taken seriously. Yet other climatologists, too, made forecasts in the eighties they no longer maintain. C. D. Schönwiese **[99]**, usually critical and cautious in his statements, still predicted in 1987 a 4.5° C rise in temperature until 2030, though only as an upper limit. He thought that the sea level in the German Bay could rise by 1.5 m till 2040 and in the ocean around India even 2 to 3 m. A projection of his temperature forecast yields **11.8° C** for the year 2100. At the climate conference in Villach in 1985 similar predictions were presented to the public. The IPCC still predicted in 1990 and 1992 that global temperature would rise **1.9° - 5.2° C** until 2100 **[100]** and thought that a rise in sea level by 1.10 m was possible **[36]**.

All these predictions have turned out to be untenable. It is accepted that global temperature has risen by **0.5° C** in the last hundred years. Yet during the last fifty years the temperature has remained approximately at the same level, even though 70% of the anthropgenic carbon dioxide contribution was injected into the atmosphere during this time. From 1940 to 1970 the temperature fell, and according to satellitite data available since 1979, which are in good accord with balloon data **[27]**, the trend in the lower troposphere has remained at **-0.06° C** per decade. The IPCC prediction made in 1992 proved so exaggerated that it had to be adjusted to reality three years later by reducing the rise range to 1° - 3.5° C by 2100. As to sea level rise, the IPCC meanwhile acknowledges (in accordance with a consensus in the specialized literature **[3]**) that sea level has risen by merely **18 cm** in the last hundred years. According to M. Baltuck et al. **[3]** it is very probable that the rising sea level is due to natural causes and not to man's contribution to the greenhouse effect.

The discrepancy between IPCC forecasts and observed data stands out very clearly as to temperatures in the polar regions. The general circulation models, presented by the IPCC in 1990, predict for the regions near the poles in a CO_2 doubling scenario a rise in temperature of more than **12° C** **[13]**. If this were true, in the last 40 years with their steep increase in CO_2 concentration, a warming trend with a temperature rise of several °C should have emerged. The opposite is true **[20]**. A joint investigation by American, Russian and Canadian scientists shows that the surface temperatures in the Arctic region observed between 1950 and 1990 are going down. They fell **4.4° C** in winter and **5° C** in autumn **[43]**. Satellite data too, available since 1979, do not indicate rising temperatures **[105]**. This agrees with data published by the world Glacier Monitoring Network in Zurich, according to which **55%** of the glaciers in high latitudes are advancing compared with 5% around 1950.

The main reason of the incompatibility of IPCC forecasts and observed data is the lacking suitability of the general circulation models (GCM) for the purpose of long-range climate predictions. GCMs are an excellent tool for research into data connections, the physics of which is just beginning to emerge. In such cases quantitative and qualitative aspects of the data pattern may be investigated which develop when the determining variables are changed. **The point here is learning, not predicting**. The development in the immensely complex nonlinear climate system with feed-back coupling of atmosphere, ocean, cryosphere, and biosphere may be forecast, if at all, only for rather short intervals.

GCMs are based on the same type of nonlinear differential equations which induced E. N. Lorenz in 1961 to acknowledge that long-range weather predictions are impossible because of the atmosphere's extreme sensitivity to initial conditions. It is inconceivable that the **Butterfly Effect** should disappear when the prediction interval of a few days is extended to decades and centuries. Some climatologists concede that there is a problem. C. D. Schönwiese **[100]** remarks in this respect:

> ***"Consequently we should conclude that climatic change cannot be predicted. It is correct that the varied and complex processes in the atmosphere cannot be predicted beyond the theoretical limit of a month via step by step calculations in circulation models, neither today, nor in the future. Yet there is the possibility of a conditioned forecast. The condition is that a special factor within the complex cause-and effect relationship is so strong in its effect that it clearly dominates all other factors. In addition, the behaviour of that single dominant causal factor must be predictable with certainty or a high degree of probability."***

The dominant causal factor, meant here, is the anthropogenic greenhouse effect. However, there is no convincing evidence that this is an outstanding factor that clearly dominates all other factors which could have an influence on climate. The results presented here indicate clearly that the sun's varying activity is at least a non-negligible factor and probably the really dominant one. Furthermore, the greenhouse effect is contrary to Schönwiese's conditions in being not predictable to a high degree of probability, as the inadequate performance of IPCC forecasts shows. In addition, it is quite uncertain when doubling of the atmosphere's CO_2 content will occur. In the eighties it was surmised that doubling would happen as early as 2030. Now J. P. Peixoto and A. H. Oort **[86]** expect doubling in 2200. Another contentious point is how long CO_2 will stay in the atmosphere, several hundred years, or only five years? New results by P. Dietze and T. V. Segalstad show that shorter residence times are much more probable than the extended ones. Moreover, J. Barrett has shown that all the energy that can be absorbed by the atmosphere is already being absorbed by the lower atmosphere (water, aerosol, and CO_2) under present conditions. Finally, it has been assumed in the GCMs that the planet's population, responsible for the anthropogenic CO_2 contribution, will grow to 11.5 billion people by the end of the next century. The recent statistical survey published by the UN, ***"World Population Prospects: The 1996 Revision"***, shows clearly that the growth expected by the IPCC is utopian and will have to be revised sharply downward, thus reducing the imagined threat dramatically. In 1950 - 1955 the global total fertility rate (the world average number of children born per woman per lifetime) was five, explosively above the replacement rate of 2.1 children. In 1975 - 1980 the fertility rate sank to four. At present it has reached 2.8 and continues to sink. In Europe the rate has fallen by 20% during the last ten years and is at 1.4 now. The same applies for Russia and Japan. The developing countries are no exception. In Bangladesh the fertility rate has fallen from 6.2 to 3.4 in just ten years. So the CO_2 output will be much lower than that estimated in the GCM calculations.

When those equations that are thought to represent the climate system are subjected to a first integration with the anthropogenic forcing kept constant so that the result can be compared with a second integration based on increasing CO_2 forcing, the outcome can be considered convincing only if the differential equations represent the physics of the climate system exactly and completely. Yet this condition is far from being fulfilled. Not only do we not know enough about a wealth of details of complex feed-back problems **[114]**, but there is also a fundamental lack of data. In addition there are technical and mathematical difficulties. J. P. Peixoto and A. H. Oort **[86]** comment aptly:

> ***"The integration of a fully coupled model including the atmosphere, oceans, land, and cryosphere with such different internal time scales poses almost insurmountable difficulties in reaching a final solution, even if all interacting processes were completely understood."***

A fatal flaw however is that tiny deviations from the ideal initial conditions may lead to quite different courses in the development of climate. C. Wiin-Christensen and A. Wiin-Nielsen **[117]** have rightly pointed out that the resulting limited predictability is insurmountable as it is linked to the given nonlinearity of the differential equations.

6. Cycles in the Sun's Oscillation Affect Sunspots and Climate

The IPCC holds:

> **“Solar variability over the next 50 years will not induce a prolonged forcing significant in comparison with the effect of increasing CO concentrations.”**

However, if, contrary to the IPCC’s attitude, the sun is taken seriously as a dominant factor in climate change, this opens up a possibility to predict climate features correctly without any support by supercomputers. A string of examples will be presented. The chaotic character of weather and climate does not stand in the way of such predictions. Sensitive dependance on initial conditions is only valid with regard to processes within the climate system. E. N. Lorenz has stressed that only non-periodic systems are plagued by limited predictability. External periodic or quasiperiodic systems can positively force their rhythm on the climate system. This is not only the case with the periodic change of day and night and the Milankovitch cycle, but also with variations in solar energy output as far as they are periodic or quasiperiodic. The 11-year sunspot cycle meets these conditions, but plays no predominant role in the practice of predictions. Most important are solar cycles which are without exception related to the sun’s fundamental oscillation about the center of mass of the solar system and form a fractal into which cycles of different length, but similar function are integrated. The solar dynamo theory developed by H. Babcock, the first still rudimental theory of sunspot activity, starts from the premise that the dynamics of the magnetic sunspot cycle is driven by the sun’s rotation. Yet this theory only takes into account the sun’s spin momentum, related to its rotation on its axis, but not its orbital angular momentum linked to its very irregular oscillation about the center of mass of the solar system (CM).

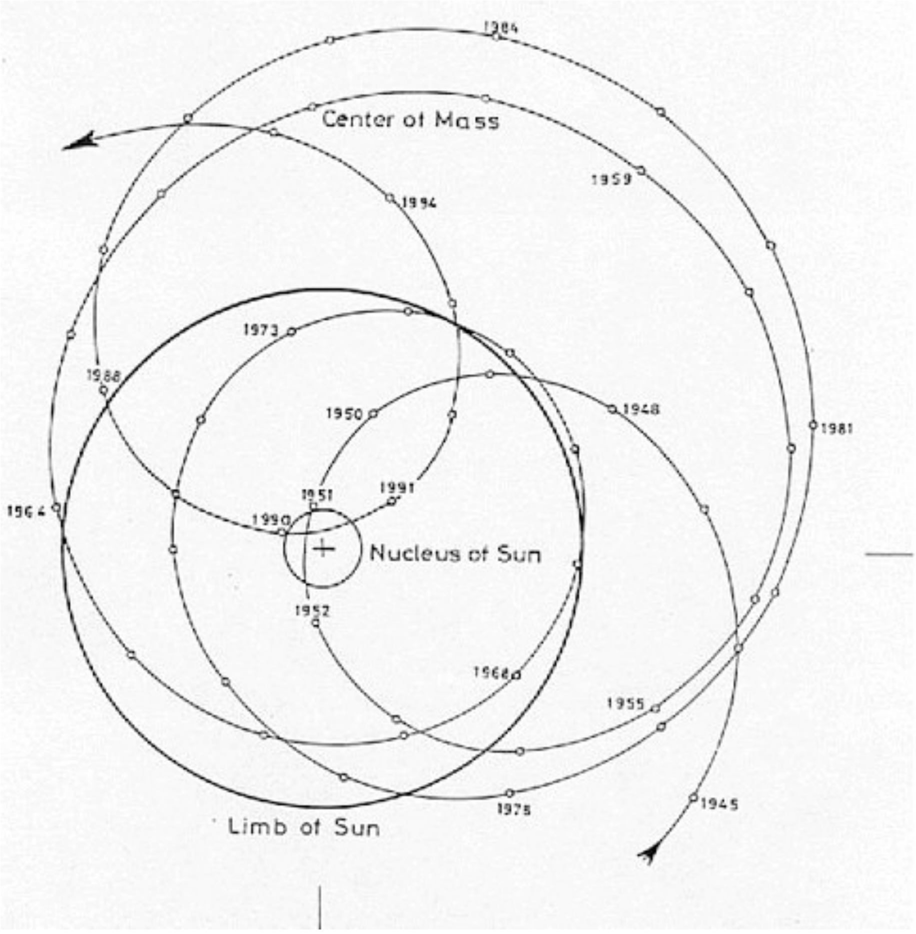

Figure 7

Figure 7 shows this fundamental motion, described by Newton [85] three centuries ago. It is regulated by the distribution of the masses of the giant planets Jupiter, Saturn, Uranus, and Neptune in space. The plot shows the relative ecliptic positions of the center of mass (small circles) and the sun’s center (cross) for the years 1945 to 1995 in a heliocentric coordinate system. The large solid circle marks the sun’s surface. Most of the time, CM is to be found outside of the sun’s body. Wide oscillations with distances up to 2.2 solar radii between the two centers are followed by narrow orbits which may result in close encounters of the centers as in 1951 and 1990. The contribution of the sun’s orbital angular momentum to its total angular momentum is not negligible. It can reach 25% of the spin momentum [60]. The orbital angular momentum varies from -0.1×10^{47} to 4.3×10^{47} g cm^2 s^{-1} , or reversely, which is more than a forty-fold increase or decrease. Thus it is conceivable that these variations are related to varying phenomena in the sun's activity, especially if it is considered that the sun's angular momentum plays an important role in the dynamo theory of the sun's magnetic activity.

Variations of more than 7% in the sun's equatorial rotational velocity, going along with variations in solar activity, were observed at irregular intervals **[54, 56]**. This could be explained if there were transfer of angular momentum from the sun's orbit to the spin on its axis. I have been proposing such spin-orbit coupling for two decades **[56, 57]**. Part of the coupling could result from the sun's motion through its own magnetic fields. As R. H. Dicke **[14]** has shown, the low corona can act as a brake on the sun's surface. The giant planets,which regulate the sun's motion about CM, carry more than 99% of the angular momentum in the solar system, while the sun is confined to less than 1%. So there is a high potential of angular momentum that can be transferred from the outer planets to the revolving sun and eventually to the spinning sun.

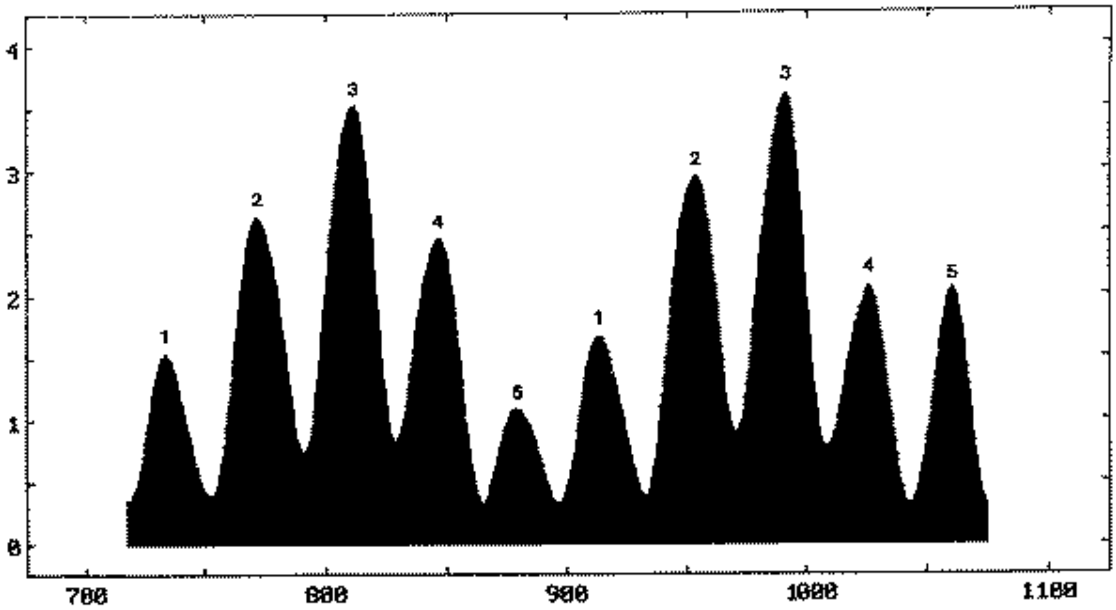

Figure 8

The dynamics of the sun's motion about the center of mass can be defined quantitatively by the change in its orbital angular momentum. The rate of change is usually measured by derivatives. In some respects the running variance yields more informative results. It applies the well-known smoothing of two, three, or more consecutive readings to variance, the square of the standard deviation. Consecutive values of the running variance draw attention to the variation in variability and accentuate dynamical processes **[98]**. Figure 8 displays the 9-year running variance of the orbital angular momentum for the years 730 to 1075. The 9-year running variance has been chosen because the narrow orbits with a stronger curvature have just this cycle length and yield interesting results. Surprisingly, the pattern in Figure 8 is shaped by a five-fold symmetry. For the sake of simplicity I call the features "big hands" and "big fingers". They emerge in a similar way in past and future millenia. Their five-fold symmetry is not their only interesting quality. They are linked to cycles which play an important part in solar-terrestrial relations. The big hand cycle has a length of 178.8 years. P. D. Jose **[41]** has shown in his pioneering computer analysis of the sun's motion that a cycle of this length appears in the sunspot data. The strongest cycle discovered by W. Dansgaard et al. **[63]** in the oxygen isotope profile in the Camp Century ice core has a length of 181 years, close to 178.8 years. This points to a relationship with climate. It is conspicuous that the Gleissberg cycle is just half as long as the big hand cycle. J. F. W. Negendank, A. Brauer, and B. Zolitschka **[83]** have found a cycle of 88 years in warves of the crater lake of Holzmaar which cover 13,000 years. The length of the cycle of a half big hand is 89.4 years. This points again to a connection with climate.

7. Cycles of 36 Years in Solar Activity and Climate

Cycles of big fingers have a mean length of 35.8 years (178.8 years [big hand] / 5 = 35.76 years [big fingers]). They are closely connected with solar activity. They coincide with maxima and minima in the Gleissberg cycle and open up the possibility of predicting these crucial phases many years ahead **[62, 63]**. As will be shown below, they also define the length of the 22.1-year magnetic cycle of sunspot activity (Hale cycle). As far as climatic change is concerned, cycles of a length of 36 years are not new. Francis Bacon **[102]** has already pointed to a cycle in the Netherlands with a length of 35 to 40 years with cool and wet phases followed by warm and dry periods. E. Brückner [7] discovered this cycle again in 1887. He demonstrated that varied climatic phenomena in different regions of the world show synchronized phases in a cycle of 33 to 37 years. He had already surmised in those days a connection with the sun's activity. H. W. Clough [11, 12] followed this suggestion and found the Brückner cycle not only in 12 meteorological variables, but also in sunspots and especially in variations in the length of the 11-year sunspot cycle. D. V. Hoyt and K. H. Schatten [39] think that the reality of the cycle is confirmed by Scandinavian tree ring data which show its rhythm over hundreds of years. With regard to Brückner's supposition of a connection with the sun's activity, they ask which index of solar activity would conform with a 36-year cycle. The results presented here answer this question.

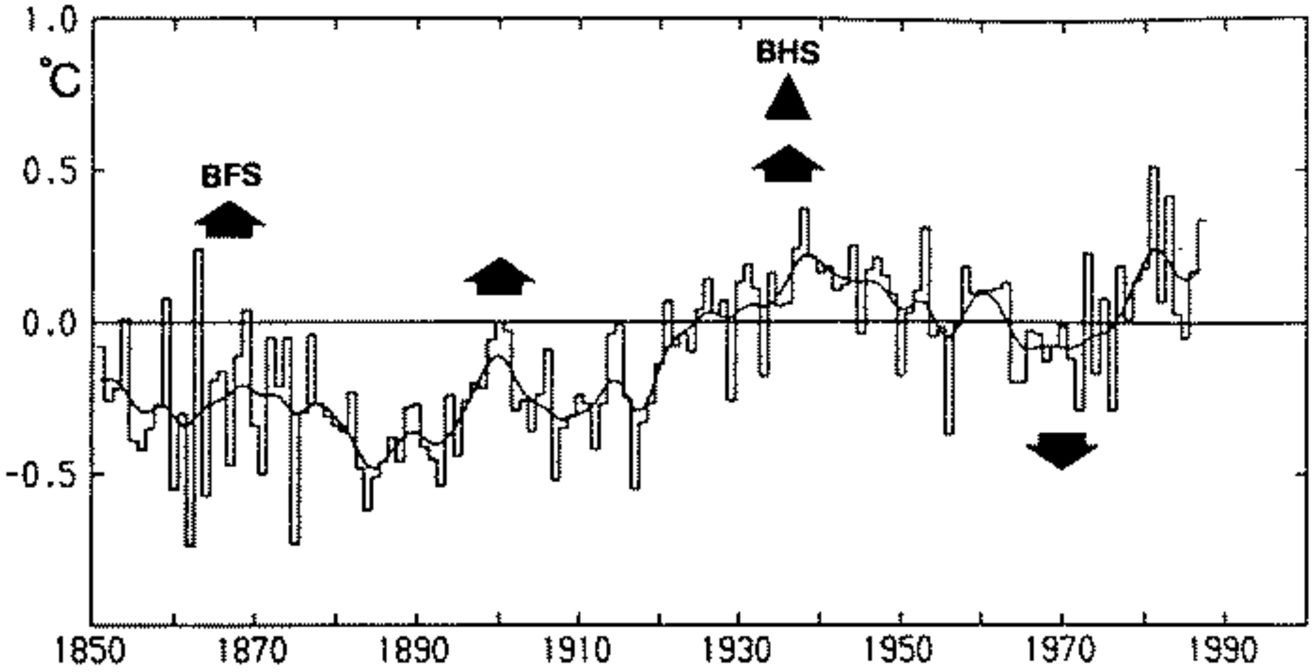

Figure 9

Figure 9 after P. D. Jones [40] shows the time series 1850 to 1987 of the annual-mean surface air temperature averaged over the Northern Hemisphere, expressed as departures in °C from the reference period 1951 to 1970. The arrows mark the start phases of big finger cycles (BFS) that fall in the data range. The triangle at the top of the plot points to the start phase in 1933 of a big hand cycle (BHS). BFSs 1867, 1901, and 1933 coincide with outstanding temperature maxima in the smoothed curve. BFS 1968, however, indicates the bottom of a downtrend that began after BHS 1933. Obviously, this is due to a phase reversal in the BFS pattern. Contrary to statistical investigations, the semi-quantitative model presented here can give an explanation that seems to solve the problem of sudden phase jumps in solar-terrestrial cycles hitherto unpredictable and unexplainable.

Experimentation with electrical and mechanical control equipment shows that at nodal points, where the response of the system is zero, the phase can shift by pi radians. The initial phase of a big finger cycle is such a nodal point. Yet it is crucial that BFS 1933 is at the same time the start of a big hand. Such nodal points higher up in the hierarchy of the fractal of cycles derived from the sun's motion about CM induce phase reversals or other forms of instability in subordinate cycles. This will be shown in a string of examples. The next BHS will be reached in 2111. So the new BFS rhythm is expected to hold for a long time. The epoch of the coming BHS phase 2007 should go along with another bottom in the global temperature.

Often the second harmonic of finger cycles is as important as the fundamental. The thickness of Lake Saki varves is related to local precipitation: the thickest warves ar linked to very wet years and the thinnest varves to very dry years [101]. I could show that maxima in the varve thickness are consistently correlated with cycles of half big fingers with a mean length of 17.9 years. The analysis covers the years 700 to 1894, nearly 12 centuries. A Monte Carlo model and Student's t-test yielded $t = 8.2$ for 33 degrees of freedom. The null hypothesis of no connection between the studied variables can be rejected at a high level of significance ($P < 6 \times 10^{-7}$) [62].

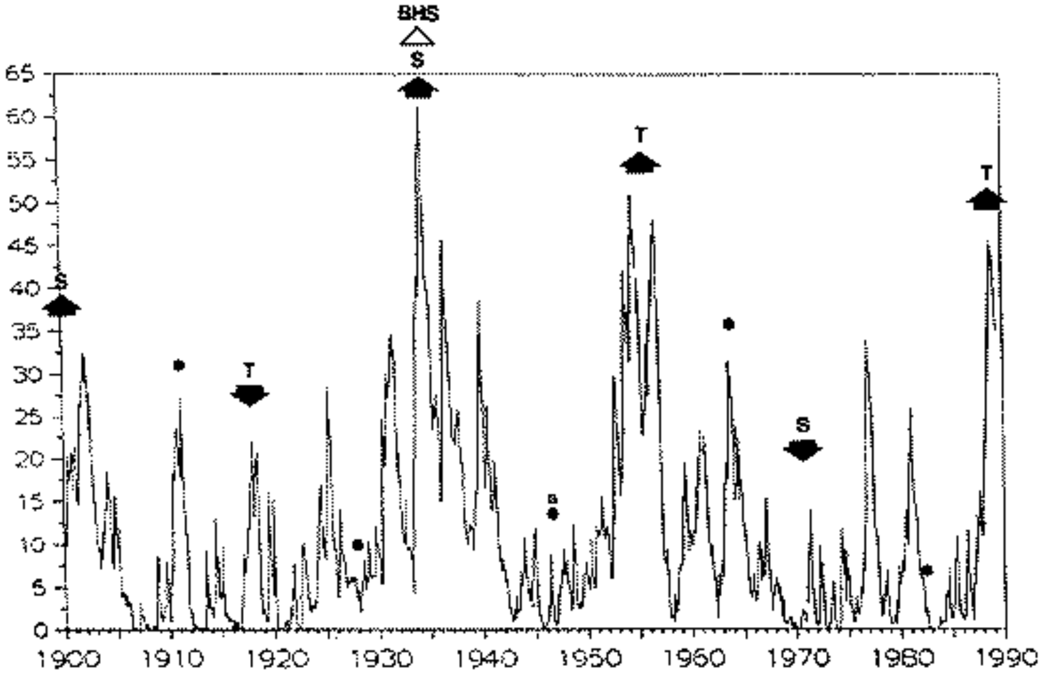

Figure 10

BFSs represent minima of the running variance in the sun's orbital angular momentum. The maxima, too, have proven relevant. I call them big finger tips (BFT). They appear in **Figure 10** which shows the Palmer Drought Index for the U.S.A. The vertical axis measures the percentage of area covered by drought. The arrows designate consecutive epochs of BFSs and BFTs. Prior to the big hand start 1933, indicated by an open triangle, the starts of big fingers (S) coincided with drought maxima and the tips (T) with minima. After BHS 1933 the correlation with the big finger phases as such continued, but a phase reversal changed the rhythmic pattern. Now BFTs coincided with drought peaks and BFSs with minima. The new rhythm has been stable since 1933. There is a good chance that it will continue until the next BHS in 2111. Farmers in the U.S.A. may expect wet climate around the next BFS in 2007.

Yet, what is the meaning of those black circles in Figure 10 which alternately go along with drought maxima and minima and are also subjected to a phase reversal? They mark the Golden section between BFSs and BFTs. The five-fold symmetry in the dynamics of the sun's oscillation about the center of mass of the solar system, visible in **Figure 8**, establishes a relationship between the sun's motion and the Golden section, as this remarkable proportion is closely related to the number 5 **[45]**. To show this intimate connection, all of the corners of a regular pentagon (the fundamental geometrical representation of the number five) are connected by diagonals. A five-pointed star emerges, a pentagram, the intersecting lines of which form a complex web of Golden sections. Within this star a new pentagram appears that contains a smaller star with further Golden section divisions, and so on, in an infinite fractal sequence.

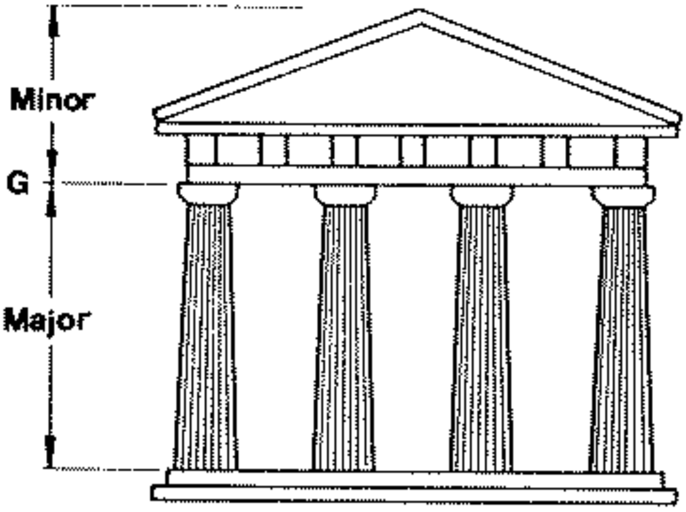

Figure 11

As illustrated in **Figure 11**, the Golden section divides a frame structure like a line segment, a surface, a cycle, or any other delimited feature so that the ratio of the whole to the larger part (major) equals the ratio of the larger part to the smaller one (minor). Point G represents the irrational Golden Number G = 0.618... It divides the unit height of the temple into major (0.618...) and minor (0.3819...). To find the major of a line segment, a cycle etc., it has to be multiplied by 0.618. Multiplication by 0.382 yields the minor. As the fundamental oscillation of the sun about CM depends on the masses and the positions of the giant planets, the relationship with the Golden section extends to the whole solar system. A. N. Kolmogorov [47], V. I. Arnol'd [1], and J. Moser [79] have proven theoretically, that the stability of the solar system hinges on the Golden section. This is crucial, as we know from publications by G. J. Sussman and J. Wisdom [110] as well as J. Laskar [67] that the orbits of all planets are chaotic. In my paper ***"The Cosmic Function of the Golden Section"*** [64] I have shown in practice how the Golden section, which stands for stability in polar opposition to instability, keeps the chaotic planetary orbits stable. The mean of the ratios of the perihelion distances of neighbouring planets from Mercury to Pluto, including the mean radius vector of the planetoids, turns out to be very close to the Golden number G. The difference between this mean and G is as small as 0.002. Fivefold quantities have deep roots in Nature. There are not four, but five physical forces. We merely have forgotten that electromagnetism is composed of different forces. First Maxwell unified electricity and magnetism and later on electromagnetism and the weak force was unified to constitute the electro-weak force [44].

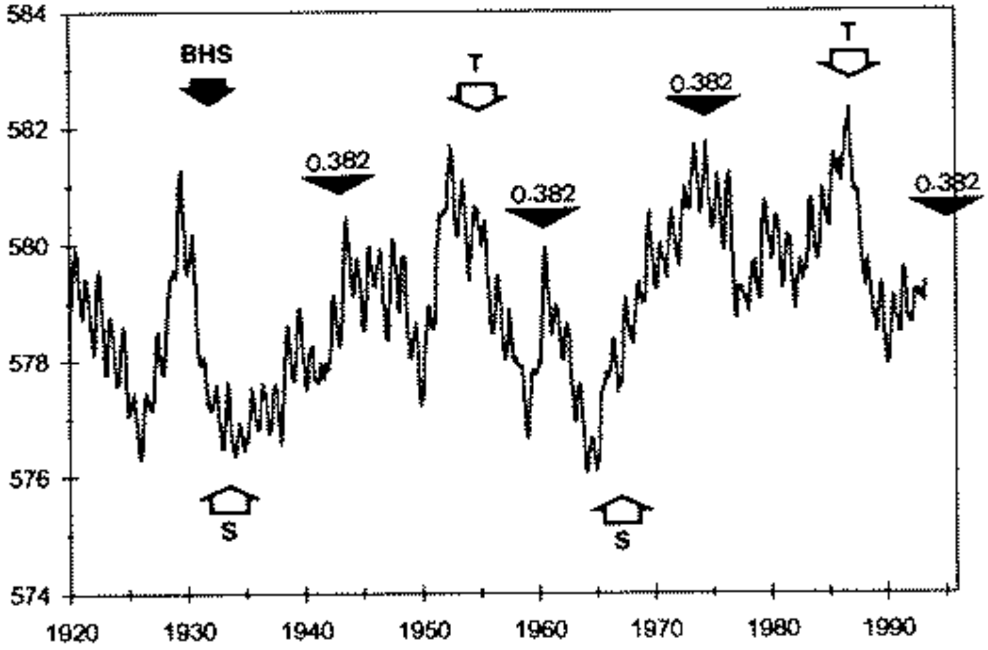

Figure 12

Figure 12 after R. Mogey [78] presents a further practical example, the Great Lake (Michigan-Huron) water levels. After BHS 1933, marked by a filled arrow, the deepest levels coincide with BFSs (S, filled arrows) and the peak levels with BFTs (T, open arrows). A deep trough in the data is to be expected around 2007 and a new peak level around 2025. The flat triangles point to secondary peak levels, related to the minor 0.382 of the Golden section between BFS and BFT phases.

The Golden section has left its mark, too, upon the 11-year sunspot cycle. Reliable data are available since 1750. They show that the ascending part of the cycle has a mean length of 4.3 years [73]. The mean cycle length amounts to 11.05 years. The minor of the mean length falls at 4.2 years (11.05 years × 0.382 = 4.22 years). This is close to 4.3 years. Thus, the maximum of the 11-year cycle falls at the minor of the Golden section. The descending wing of the cycle has the length of the major. This contributes to the stabilization of solar activity which is characterized by phenomena generated by instability.

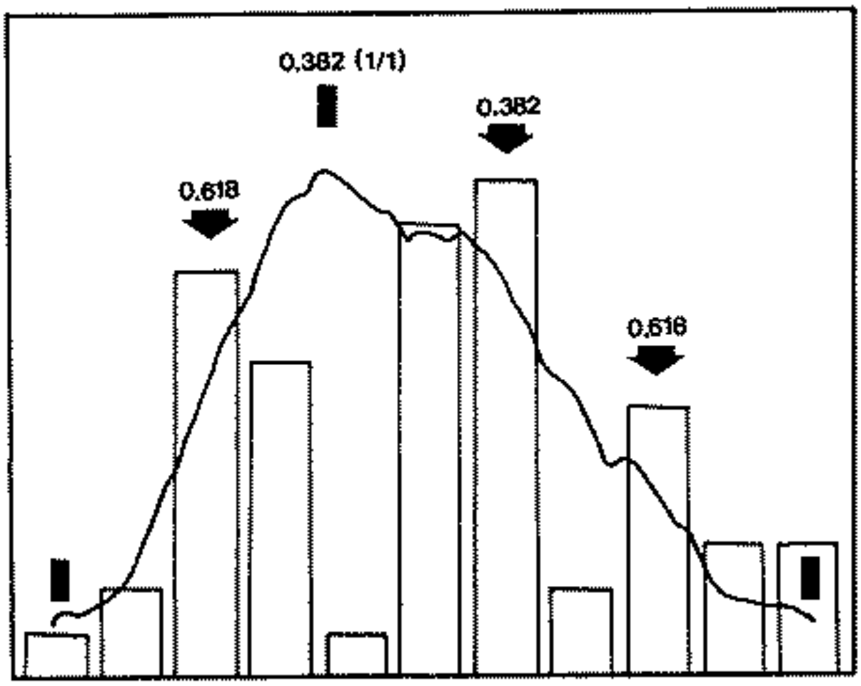

Figure 13

Magnetic cycles of solar type stars show the same structure shaped by the Golden section **[64]**. The histogram in **Figure 13** after EOS **[18]** shows the distribution of higly energetic solar eruptions within the 11-year cycle. The accents are set by the Golden section within the subcycles formed by the ascending and descending part of the whole cycle. This pattern recurs in terrestrial cycles. The three curves in **Figure 14** after H. H. Lamb **[52]** connect the 11-year sunspot cycle with thunderstorm activity in central Europe. At the top of the plot, consecutive sunspot minima and the maximum in between are marked by small arrows. The upper curve presents for 1810 to 1934 the number of days with thunderstorm activity in Kremsmünster, the curve in the middle for 1878 to 1934 the thunderstorm frequency in Vienna, and the curve at the bottom the number of houses struck by lightning in Bavaria between 1833 and 1879. The peaks in all of the curves fall at minor and major of the solar subcycles. These Golden section phases are marked by open triangles.

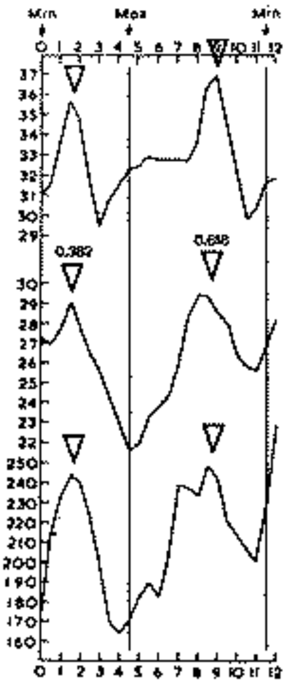

Figure 14

The magnetic sunspot cycle of 22.1 years, also called the Hale cycle, is the true cycle of solar activity. Groups of sunspots are usually composed of preceding and following spots with different magnetic polarity. With the commencement of a new cycle the polarity reverses. Thus, the original polarity is only restored every second 11-year cycle. When the position of the major of the Golden section within a big finger cycle is calculated, it falls just at the length of the Hale cycle (35.76 years × 0.618 = 22.1 years). This helps to limit the instability which is inherent in solar activity. In climate, the Hale cycle is a dominant feature in the global record of marine air temperatures, consisting of shipboard temperatures measured at night **[9]**, in the detrended Central England temperature record for 1700 to 1950 **[72]**, and in the drought severity index covering different areas of the Western United States **[77]**. The major of the Golden section within the cycle of the big hand (178.8 years × 0.618 = 110.5 years) yields a similar result. Japanese scientists found a cycle of just this length in sunspots when they applied a frequency analysis to the data **[120]**.

8. Cycles of “Small Fingers”: a Solid Basis for Predictions of Solar Eruptions and Climate

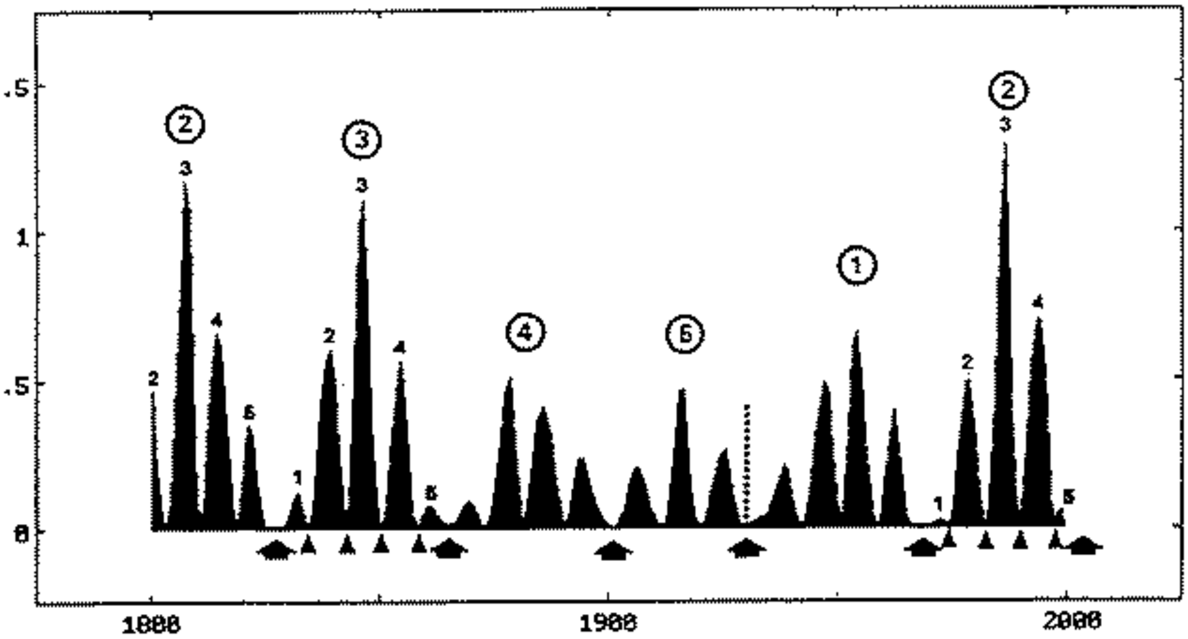

Figure 15

A ubiquitous notion in present day science is the term fractal coined by B. B. Mandelbrot. A fractal is a geometrical shape whose complex structure is such that magnification or reduction by a given factor reproduces the original object. Self-similarity on different scales is a pre-eminent feature of fractals. The solar cycles derived from the sun’s motion about the center of mass form such a fractal. The big fingers in big hands contain small hands with small fingers (SF). This becomes apparent by further amplification. **Figure 15** shows the 3-year running variance of the sun’s orbital angular momentum. The circled numbers at the top mark epochs of BFTs. Tips of small fingers (SFT) are indicated by small numbers. Fat arrows and small triangles point to starts of big and small fingers. The vertical dotted line marks the initial phase of a big hand in 1933. The theoretical mean length of cycles of small fingers is 178.8 years / 5 / 5 = 7.2 years. Yet small fingers show a higher degree of “morphological” anomalies. There are sometimes hands that have only three or four fully developed fingers. There is a wider range of deviations from the mean length of small finger cycles. However, all of these variations can be computed and predicted.

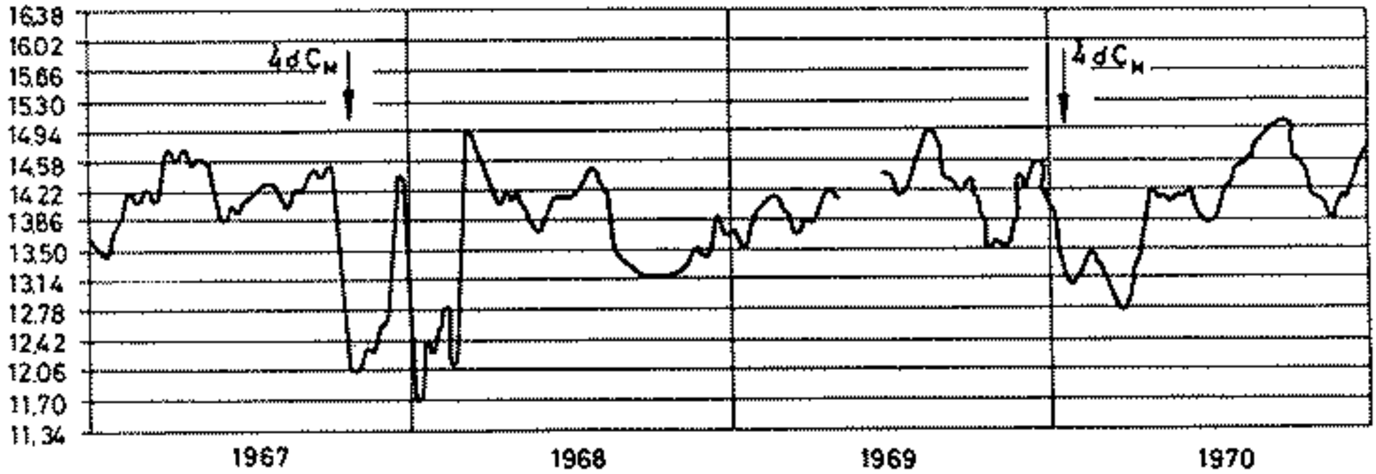

Figure 16

The starts of the small finger cycle (SFS) are of special importance. The sun’s orbital angular momentum L reaches extrema in these phases and dL/dt becomes zero. In **Figure 16** after R.

Howard [37] two such initial phases at the end of 1967 and the beginning of 1970 are shown. They were initiated by heliocentric conjunctions of Jupiter, by far the largest of the giant planets, with the center of mass CM. The vertical axis measures the sun's rotational velocity. In both of these cases a striking jump in the sun's rotation occurred. In former decades this phenomenon, too, was observed [54]. As the sun's rotation on its axis and the sun's activity are connected, it is not surprising that energetic solar eruptions accumulate around SFSs, as I could show in a paper published in 1976 [54]. This relationship is so reliable that predictions can be based on it. My long-range forecasts of strong solar eruptions and geomagnetic storms, covering six years, achieved a prediction quality of 90% though such events occur at quite irregular intervals. Out of 75 events from quantitatively defined categories, 68 occurred at the predicted time [57, 60, 61]. The outcome of the forecast experiment was checked by the astronomers W. Gleissberg, J. Pfleiderer, and H. Wöhl as well as the Space Environment Services Center in Boulder, Colorado. The very strong geomagnetic storms in 1982 and around 1990 were also correctly predicted several years before the event [56, 60].

Forecasts of energetic solar eruptions are of importance for weather and climate too, as they enhance the solar wind and weaken the galactic cosmic radiation, which according to Svensmark and Friis-Christensen have a strong impact on cloud coverage. So it is no longer inexplicable that I correctly predicted at an international climate symposium in Boulder, three years before the event, that the Sahelian drought would end in 1985 [55].

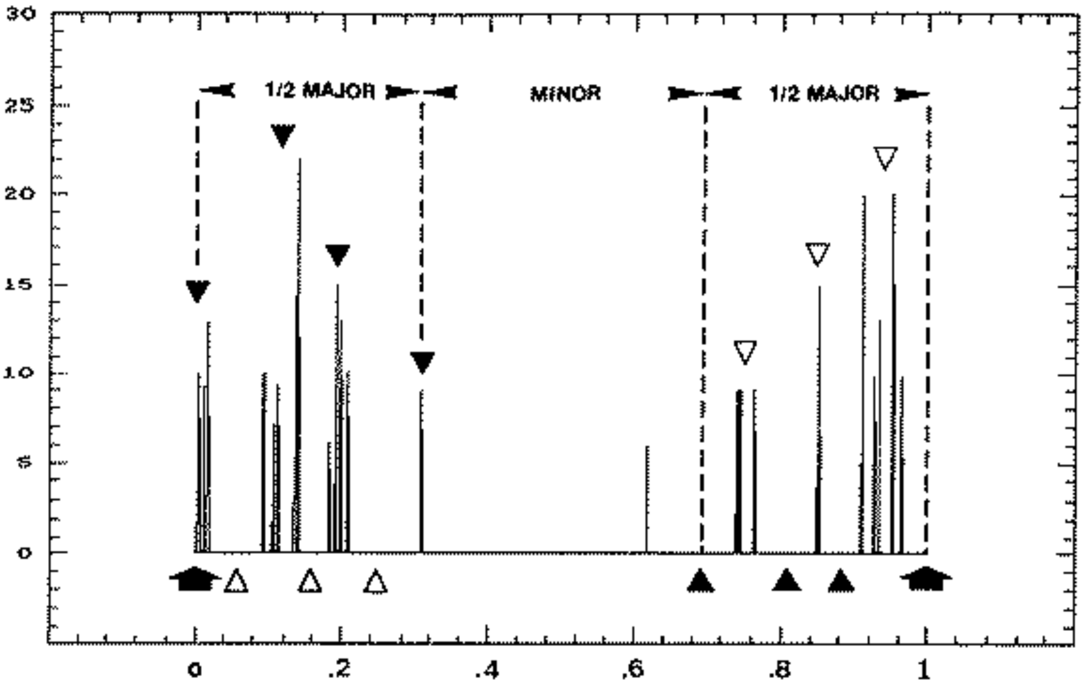

Figure 17

Figure 17 shows how closely cycles of small fingers and energetic solar eruptions are connected. The plot presents the distribution of all X-ray eruptions X => 6 [81], observed from 1970 to 1996, within the normalized small finger cycle. Intense X-ray eruptions have a stronger impact than flares categorized into classes of optical brightness. Fat arrows mark consecutive initial phases SFS of the cycle. It is conspicuous that the eruptions concentrate on a restricted range before and after SFS. This is already enough to base a rough prediction on. Yet a much more differentiated pattern emerges when the Golden section is taken into consideration. In the plot, one half of the major of the Golden section lies after the first SFS and the second half before the next SFS, whereas the minor is arranged in between. The filled triangles pointing downwards after the first SFS indicate the phases on which the eruptions concentrate. They lie just after the first SFS, at the boundary of the first half of the major, and at minor and major within this range. The open triangles pointing upwards just in the middle between the filled triangles indicate lulls in eruption activity. In the half minor range before the following SFS everything is reversed. The patterns before and after SFS are antisymmetric. The probability that this distribution is due to chance is P = 1.3 x 10^{-15} , though the sample comprises only 33 very energetic X-ray eruptions. When 163 X-ray eruptions in the range X = 2 to X < 6 [81] are investigated to check the pattern in Figure 17, the sceptical null hypothesis can be rejected at the level P = 7 x 10^{-10}. 197 X-ray eruptions in the range X = 1 to X < 2 yield P = 2.7 x 10^{-11} . The relationship is so manifest that dependable predictions can be based upon it.

After the publication of this result, a further strong eruption, an X9 flare, occured on November 6, 1997. It fell exactly at one of the active phases in Figure 17.

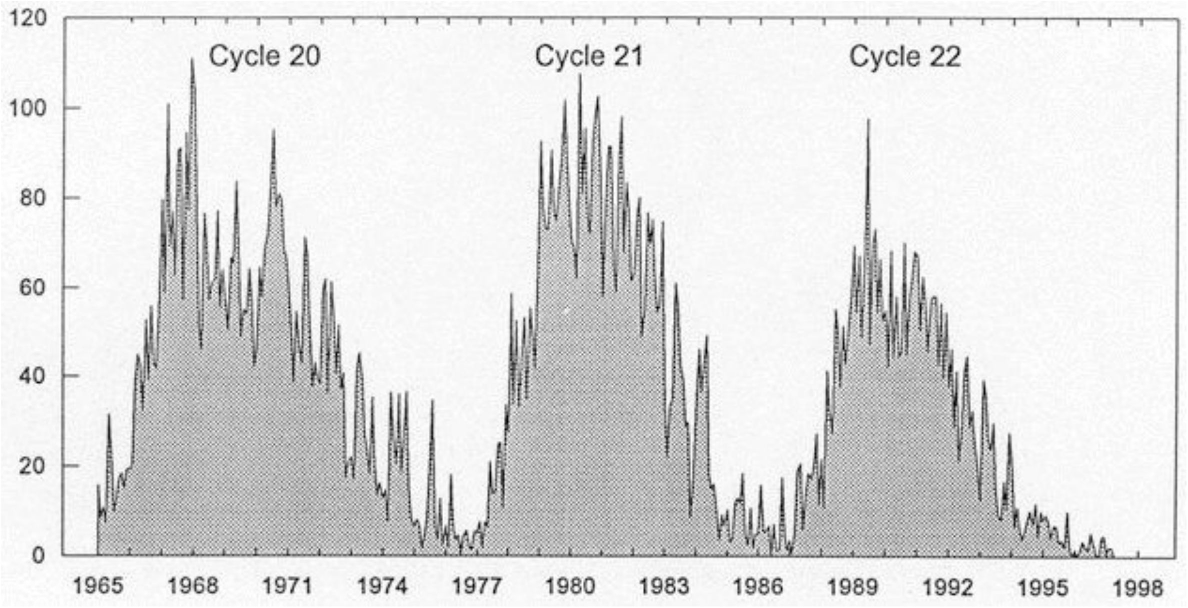

Figure 18

The primary cause of the solar modulation of cosmic rays, which regulates cloud coverage, is not the number of sunspots, but the varying strength of the solar wind. This was mentioned already. The highest velocities in the solar wind up to 2500 km/sec are generated by energetic solar eruptions (solar flares and eruptive prominences) which even contribute to cosmic rays. These solar cosmic rays have an impact on the strength of the solar wind, but show fluctuations different from the galactic cosmic rays that enter the solar system from the outside. Energetic solar eruptions shun sunspot maxima **[18]** and occur even close to minima. The number of eruptions does not depend proportionally on the intensity of 11-year sunspot maxima. **Figure 18** from Solar Geophysical Data **[106]** displays the monthly numbers of observed flares in sunspot cycles No 20 to 22.   Cycle No 20 with the highest monthly sunspot number R = 106 was much weaker than cycle No 21 (R = 165) and cycle No 22 (R = 158), but it produced nearly as many flares as cycle No 21 and considerably more than cycle No 22. It is surprising, too, that cycle No 22, nearly as strong as cycle No 21 as to sunspots, generated such a low number of flares in relation to its predecessor. Solar-terrestrial connections like the Svensmark effect are much more dependent on energetic eruptions than on sunspots. Sunspot maxima are not predominant in this respect, but special phases in the small finger cycle, as shown in Figure 17, are.

A wealth of publications points to a connection between geomagnetic storms and weather **[60, 103, 113, 118]**. So it is informative that there is a close correlation, too, between the velocity of the solar wind and the Kp index of geomagnetic activity (r = 0.74) **[46]**. Geomagnetic storms, on the other hand, are closely related to solar eruptions, as satellite observations show which follow the causal chain from outbursts of energy on the sun’s surface to disturbances of the earth’s magnetic field. Reference for many cases of direct connections between solar eruptions and weather phenomena is given in the literature. A typical example are the investigations by R. Scherhag **[96]** and R. Reiter **[92]** which show that the quality of weather forecasts deteriorates significantly at the time of solar eruptions. The described effects are not negligible. M. Bossolasco et al. **[6]**, for example, observed an increase in thunderstorm activity by 60% after solar eruptions. Such effects of solar eruptions, well known for decades, should be taken seriously by the IPCC, particularly since the Svensmark effect alone has a stronger weight than the anthropogenic greenhouse effect.

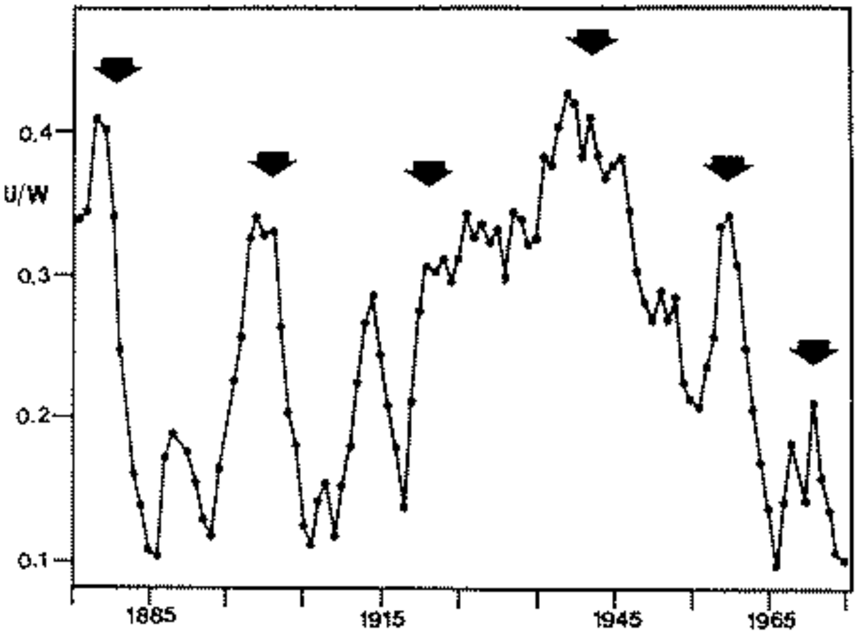

Figure 19

It has been mentioned already that Hoyt and Schatten included structural changes in sunspots when they built their model which reflects the connection between varying solar irradiance and global temperature on earth. Large sunspots have a clearly distinguishable dark inner zone, the umbra, and a less dark surrounding area, the penumbra. The ratio of the areas occupied by umbra and penumbra varies continuously. The dynamical causes are not yet known. D. V. Hoyt **[38]** connects these structural variations with the strength of convection below the sun's surface. Sunspots are embedded in the convective zone. The penumbra becomes less extended when the convection increases and a more extended penumbra indicates a weaker convection. There is a link to climate since stronger convection enhances the sun's irradiance. **Figure 19** after D. V. Hoyt **[38]** shows the ratio of the umbra area to that of the whole spot (U/W) derived from Greenwich Observatory data. Hoyt and Schatten **[39]** rightly emphasize that the U/W curve resembles the global temperature curve shown in Figure 9.

The arrows in Figure 19 indicate initial phases of small finger cycles in which the difference forces are balanced just for a moment before gravitation begins to prevail. The sun's orbital motion about CM is governed by difference forces as well as the planets' course around the sun. These forces, gravitation and centrifugal force, are balanced overall. Yet in single phases of the orbit one force or the other can prevail. This has an effect on the sun's activity. I have shown that solar flares are subjected to a directional effect which is independent of the sun's rotation on its axis. When the sun moves away from CM after a strong impulse of the torque in its orbital motion, two times as many flares are observed on the sun's side pointing away from CM than on the opposite side. When the sun moves towards CM, the number of flares on the side pointing to CM is significantly greater than on the other side. Yet this effect occurs only if the strength of the respective impulse of the torque in the SFS phase goes beyond a precisely defined quantitative threshold **[54, 57, 60]**. The SFSs in Figure 19, indicated by arrows, coincide within the whole investigated interval of a century with peaks in the U/W values. This points to a close relationship between SFSs and the strength of solar convection. The respective SFSs beyond the time frame of Figure 19 fall at 1983.1, 1998.3, and 2008.4.

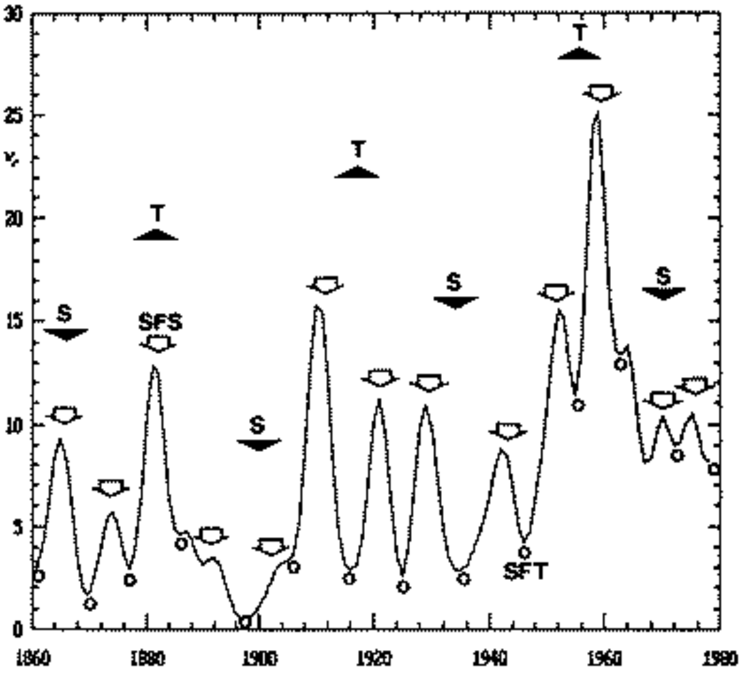

Figure 20

Figure 20 shows how big and small fingers interact with regard to climate data. The curve displays the smoothed 2-year running variance of yearly rainfall totals covering the years 1851 to 1983 derived from 14 German stations by F. Baur **[5]**. Open arrows mark epochs of SFSs correlated with maxima in the variance, while open circles indicate epochs of SFTs that go along with minima. Only at the secular sunspot minimum of 1895 is the correlation weak, probably because of the lack of releasable magnetic energy available only in large sunspot groups. In statistical tests the sceptical null hypothesis was rejected at the level P = 3 x10^{-5} **[60]**. This result was corroborated by rainfall data from England, Wales, U.S.A., and India as well as by similar investigations into temperature **[60]**. The variance amplitudes are modulated by starts (S) and tips (T) of big fingers, marked by flat triangles. BFTs show a correlation with high amplitudes and BFSs with small ones. They indicate maxima and minima that would emerge if the curve were smoothed. The next maxima in the curve are to be expected in 1998 with an amplitude in the medium range and in 2005 with an amplitude in the lower range.

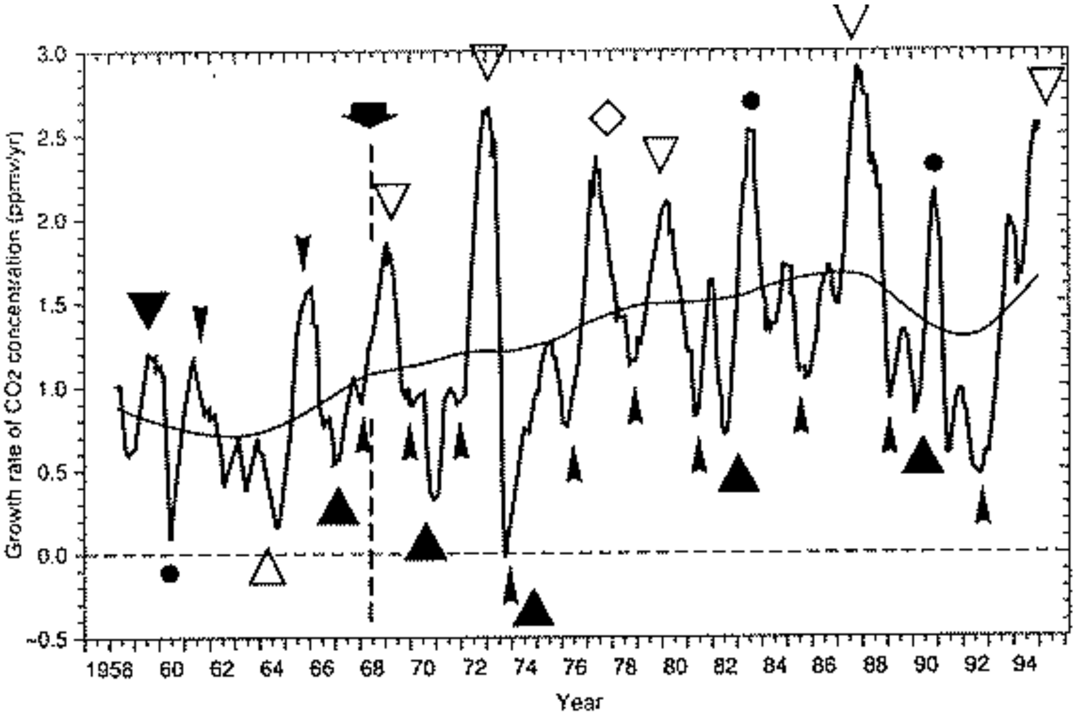

Figure 21

Figure 21 after J. T. Houghton et al. **[36]** shows the growth rate of CO_2 concentrations since 1958 in ppmv/year at the Mauna Loa, Hawaii station. I owe the result presented here to P. Dietze who drew my attention to the fact that the CO_2 data reflect the rhythm of small finger cycles in a similar way as tropospheric temperatures measured by satellites (Figure 23). Filled triangles in Figure 21 mark SFSs and open triangles the major 0.618 within the SF cycles. If the length of the cycle goes beyond 8 years, the minor 0.382, too, gets involved. It is marked by diamonds. After BHS 1968 (fat arrow and dashed vertical line) all Golden section phases (open triangles and diamond) coincide with outstanding maxima in the CO_2 data. SFSs (filled triangles) indicate deep minimum ranges. Just in the middle between the marked phases (little arrows) is the location of secondary minima. Before BHS 1968, which released a phase jump, everything is reversed. Two CO_2 maxima on the right, marked by filled circles, do not match the pattern. They lie about six months past those SFSs that coincide with middle-range maxima in global temperature shown in Figure 23. This is a confirmation of the result, elaborated by C. Kuo et al. **[48]** and H. Metzner **[75]**, that warming of the atmosphere comes first and only five to seven months later the CO_2 concentration follows. Yet it can be seen in addition that the sun's activity is involved. The next CO_2 minimum is to be expected around 1998.3, the imminent SFS, and the next maximum around 2002.9, the Golden section phase 0.618 in the new small finger cycle. An intermittent maximum like that at the end of 1990 could possibly develop around the end of 1998.

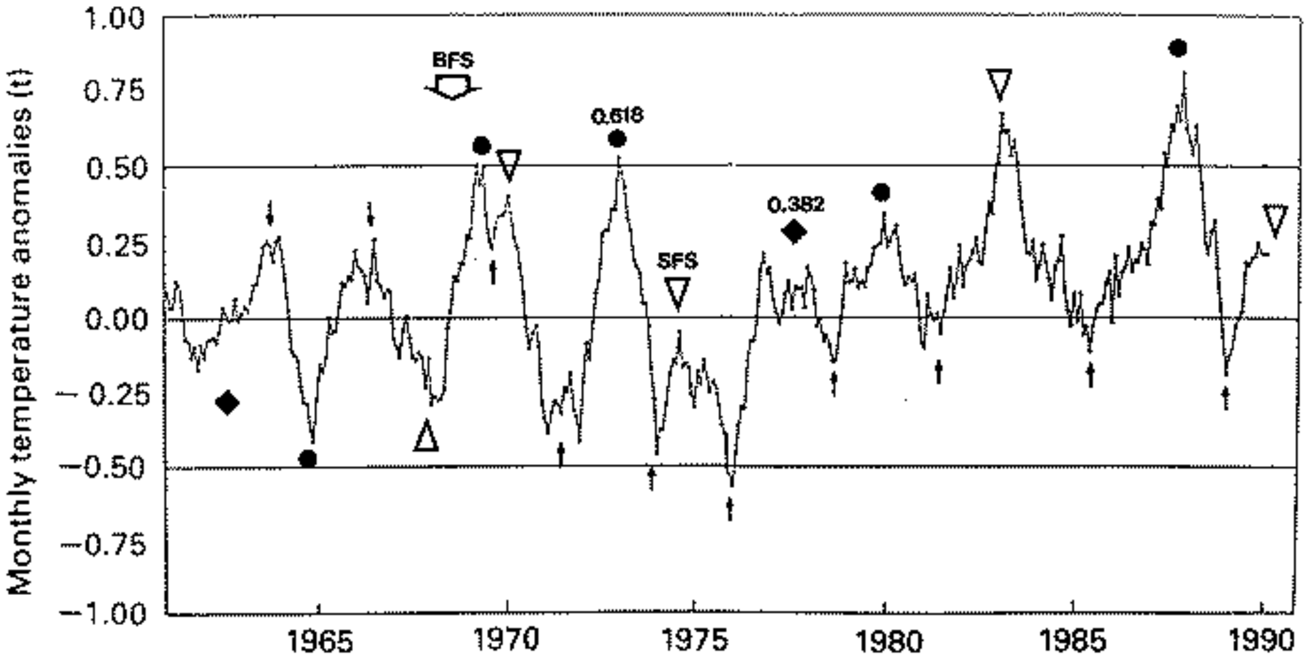

Figure 22

The connection presented in Figure 22 after J. T. Houghton et al. **[35]** solves a seemingly intractable problem of climatology and meteorology: the prediction of El Niño. This phenomenon represents a quasicyclic large scale atmosphere-ocean interaction which has climatic effects throughout the Pacific region and far beyond. It is the only true global-scale oscillation that has been identified so far. It is also called an ENSO event because of its links with the Southern Oscillation, a fluctuation of the intertropical atmospheric oscillation. The curve plots the monthly sea surface and land air anomalies 1961 to 1989 for the tropical zone extending from 20° N to 20° S. The outstanding peaks indicate ENSO events. After BFS 1968, marked by a big open arrow, all SFSs, indicated by open triangles, coincide with peaks in the plot. The same is true for the major of the Golden section within cycles formed by consecutive SFSs. These 0.618 phases are marked by filled circles. In case of small finger cycles longer than 8 years, also the minor 0.382 goes along with peaks. It is indicated by filled diamonds. Troughs in the time series are almost exactly linked to midpoints in between consecutive crucial phases, marked by small arrows.

Before the initial phase 1968 of a big finger cycle higher up in the hierarchy of the fractal of solar cycles, the pattern was reversed. SFSs as well as majors and minors within small finger cycles coincided with troughs, and the midpoints between these phases went along with peaks. A further El Niño was to be expected in 1993. It appeared punctually. In my paper ***"The Cosmic Function of the Golden Section"*** **[64]** I extrapolated this pattern and predicted more El Niños for 1995 and 1998. Critics were sceptical about the 1995 event so close after the 1993 El Niño. Yet the forecast proved correct **[26]**. A new El Niño began to build up in 1997. At the end of 1997 the Australian Bureau of Meteorology thought that El Niño had faded away and La Niña would reign in 1998. However, as the new year opened, El Niño charged up again, contrary to the predictions of its early demise, and showed a strong performance in the following months, stronger than in the months July to December 1997.

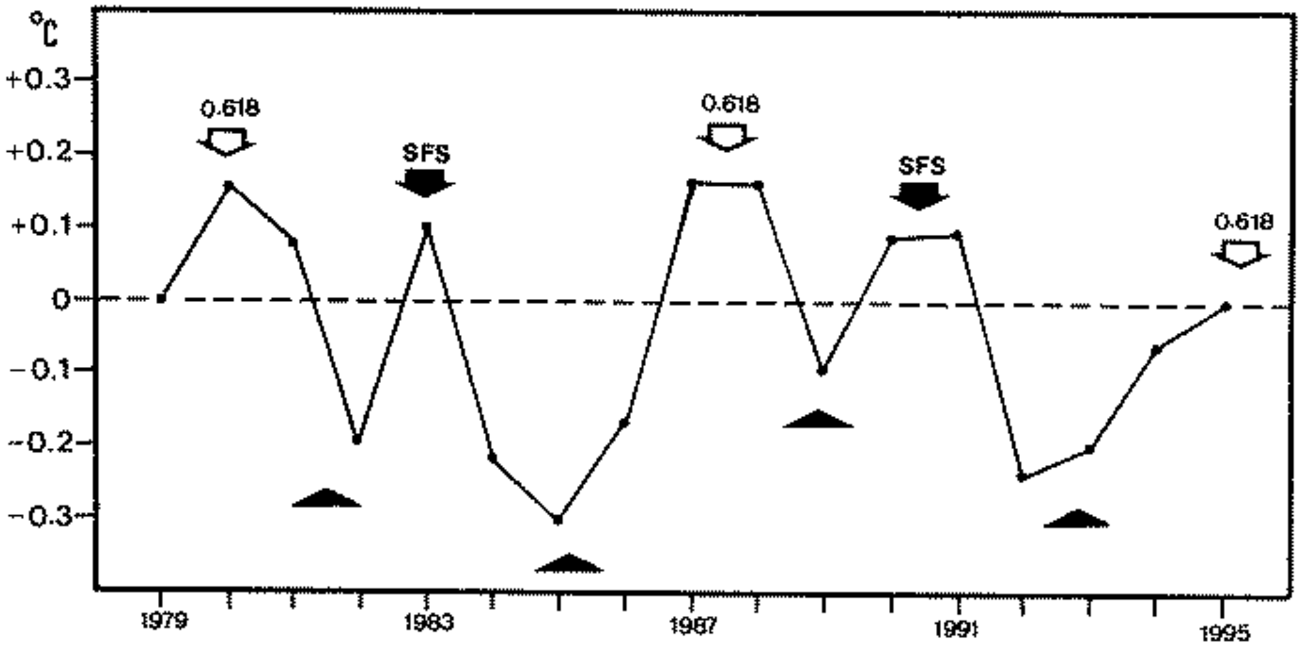

Figure 23

Figure 23 shows yearly means of the global mean temperature in the lower troposphere observed by satellites **[108]**. In contrast to time series of “world temperature” constructed by IPCC scientists, these data are objective and free from distortions by the urban heat island effect. Different from the inhomogeneous and wide-meshed net of meteorological stations they cover the whole globe homogeneously. As can be seen from Figure 23, the temperatures in 1995 were not higher than in 1979 at the beginning of satellite observations, though IPCC scientists claim an unprecedented rise in global temperature in the eighties. The trend amounts to -0.06° C per decade. The quality of the satellite data is confirmed by radiosonde observations. For the same interval these balloon data yield nearly the same trend of -0.07° C **[27]**. Both of the data series show exactly the same course **[76]**. The cyclic variation in the data cannot be explained by general circulation models in spite of the entailing great expense. There is not even an attempt to model such complex climate details, as GCMs are too coarse for such purposes. When K. Hasselmann (a leading greenhouse protagonist) was asked why GCMs do not allow for the stratosphere’s warming by the sun’s ultraviolet radiation and its impact on the circulation in the troposphere, he answered: ***“This aspect is too complex to incorporate it into models”*** **[8]**. Since there are other solar-terrestrial relationships which are “too complex” such as, for example, the dynamics of cloud coverage modulated by the solar wind, it is no wonder that the predictions based on GCMs do not conform to climate reality.

However, if the sun’s dominant role in climate change is acknowledged, the further development of the time series in Figure 23 can be predicted. The filled arrows mark SFSs. Consecutive SFSs form cycles that can be subjected to the Golden section. The 0.618 phases within the small finger cycles are indicated by open arrows. All temperature maxima coincide with the phases marked by triangles. The midpoints between the crucial phases, designated by flat triangles, go along with minima in the temperature. On the basis of this pattern I predicted a middle-range minimum in the global temperature as measured by satellites for 1997.0 and a maximum for 1998.6 **[66]**. As to the minimum, the forecast has proven correct. Record-breaking minus temperatures were observed worldwide. The maximum prediction, too, has a good chance to turn out to be right. El Niño will take care of it. The current ENSO event and rising temperatures are interpreted by IPCC scientists as a case for the human impact on climate. Yet if this were true, how could the El Niño and the current warming be predicted by looking at cycles of solar activity?

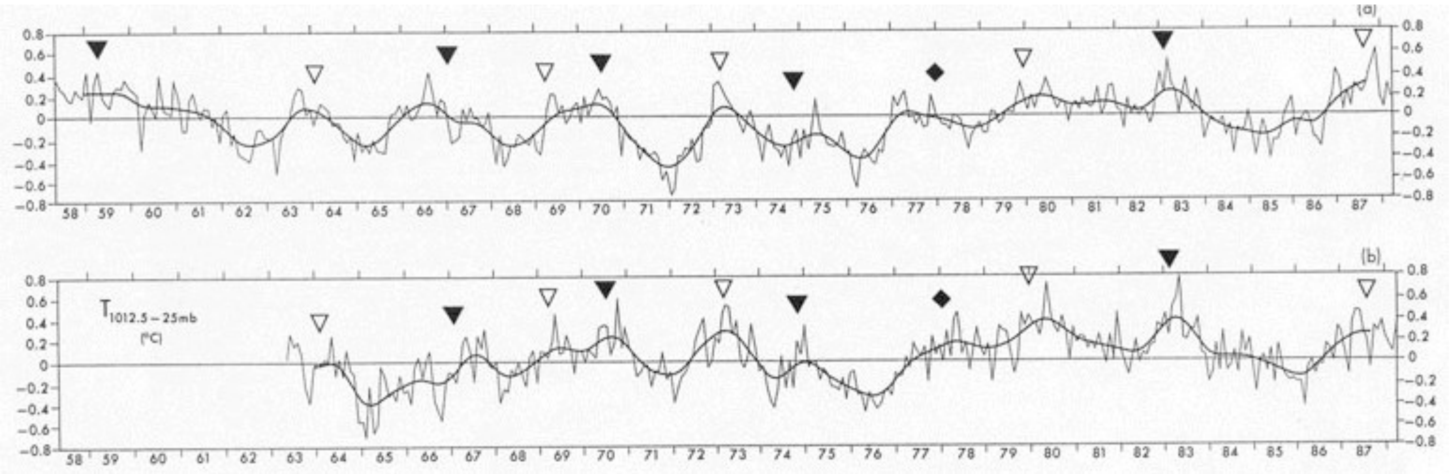

Figure 24

In spite of the successful prediction of the middle-range temperature minimum 1997.0 it is to be expected that there will be objections that the relationship shown in Figure 23 covers only 18 years. Satellite data that start earlier are not available. Yet it would be possible to make use of time series of surface temperatures to check the correlation. They reach considerably higher levels, but H. Gordon **[27]** has shown that satellite temperatures and surface time series have nearly coincident phases. An even better match are balloon-borne radiosonde data **[76]**. **Figure 24** after J. P. Peixoto and A. H. Oort **[86]** is based on such data and extends the investigation back to 1958. The curve presents the monthly-mean atmospheric temperature anomalies in °C averaged over the Northern (top) and Southern (bottom) Hemispheric mass between the surface and about 25-km height for the period May 1958 to April 1988. The range of observation includes 22 km-height that plays an important part in the quoted investigations by K. Labitzke and H. van Loon. The anomalies are taken with respect to the 1963 - 1973 mean conditions. The smoothed curves show 15-month Gaussian-type filtered values.

Data for the Southern Hemisphere are not available before 1963. The filled triangles mark SFSs and the open triangles the Golden section phase 0.618 within cycles formed by consecutive SFSs. When the cycle length goes beyond 8 years, the minor phase 0.382 is indicated by filled diamonds. The correlation between the temperature maxima and the designated phases of small finger cycles is close. As far as there are deviations they only amount to a few months. Northern and Southern Hemisphere also show a good conformance. This corroboration, which extends the satellite data result to four decades, indicates that the connection between middle-range temperature extrema and active phases of small finger cycles is real, particularly since it is part of a complex web of interrelations, the components of which confirm each other.

If we bear in mind that the correct forecasts based on the semiquantitative model of solar-terrestrial relations presented here are thinkable only if the sun's varying activity is a dominant factor in climate change, it seems difficult to resist the insight that once again an artificially constructed homocentric position is beginning to rock. A general survey of the given results indicates that climate variations are governed by the sun, not mankind.

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