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WATER RESOURCE AND FLOOD STUDIES

Causal linkages between solar activity and climatic responses

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This report is my independent contribution to the current climate change debate. The purpose is to provide linkages between climatic processes and hydrometeorological responses. This is required for the reconciliation of climate change theory with observational deductions derived from extensive studies of a comprehensive South African database.

I have neither requested nor received any financial or material support from any source in connection with these studies.

Summary for non-technical readers

South Africa has a wide range of climatic conditions from winter rainfall in the south to summer rainfall over most of the country. It has high rainfall in the east and desert conditions in the west. Most of the country has mean annual rainfalls that are well below the world average. The year-to-year variability in rainfall increases with increase in aridity. A consequence is the wide variety of the natural animal and plant life that has adapted to these mainly dry and variable conditions.

Human activity is less flexible. Both agriculture and the provision of water supplies are vulnerable to **sequences of years** with below average conditions, (droughts). As long ago as the 1920s, commissions of enquiry were appointed to investigate the causes of the droughts and their agricultural consequences. Without exception, they reported that there was no evidence of a decrease in rainfall over South Africa. Studies undertaken by engineers in the 1950s and climatologists in the 1980s confirmed that there was no evidence of decreases in rainfall.

My own studies reported here and in other publications during the past year, show for the first time that there has been a small, but nevertheless consistent **increase in rainfall** over most of South Africa during the 80-year period of continuous records.

As South Africa approaches the limits of exploitable water resources there is an urgent need to achieve a greater understanding of the causes and properties of the sequences of years with below average river flow. This problem is as old as civilisation itself. More than three thousand years ago the ancient Egyptians were well aware of the existence of these sequences, their approximate length, and their predictability. This knowledge was no doubt the source of Joseph's biblical prophecy of seven years of plenty followed by seven years of famine.

During the 1800s severe famines occurred in India and caused the loss of millions of lives. It was observed that there was an apparent linkage between the occurrence of the famines and sunspot activity. This was studied and reported by British astronomers and others. Climatology had not developed as a separate field of study.

In 1889 the South African forester D.E. Hutchins, who had served in India at the time of the famines, examined South African temperature and rainfall records and found a similar linkage with sunspot activity. He published details in his book ***Cycles of drought and good seasons in South Africa***.

Then, in 1892 Lord Kelvin in a presidential address to the Royal Society precipitated a rift between theoretical scientists who maintained that variations in solar activity were too small to be the cause of the climatic variations, and those who produced solid evidence to the contrary. This rift between theoretically based process theory, and observation theory solidly based on historical records, continues through to the present day.

Climate change science is almost exclusively based on process theory. The theory rests on the assumption that human activity, principally coal-fired power stations, industrial activity and motor transport, emit undesirable gasses (mainly carbon dioxide) into the atmosphere. This creates a 'blanket' that upsets the balance between radiation received from the sun, and that radiated from the earth back into space. As a result the earth heats up by a very small amount, which nevertheless has resulted in the Arctic and Antarctic ice sheets and terrestrial glaciers starting to melt. This warming has another measurable result. As the ocean surfaces get warmer,

evaporation increases and returns to earth as increased rainfall. This confirms my observations of an increase in rainfall over South Africa.

It is at this point that there is a divergence between modern climate change theory and centuries of real world observations. The Intergovernmental Panel on Climate Change (IPCC) was established in 1988. Its first action was to call for a scientific report so that the facts about global warming could be established. It was considered imperative that political decision makers were given a solid scientific base from which to develop the requirements for action. The IPCC issued several reports, the most important being its ***Summary for Policymakers*** distributed in 2001. Dire predictions were made and repeated by South African researchers in this field.

Among the predictions of the South African researchers were that South Africa's climate would become **warmer and drier** as a result of global warming. This would have a profound effect on the nation's prosperity through increases in damaging floods and droughts. Among the consequences would be threats to agriculture, water supplies, human health the natural environment.

It was claimed that all the observed 'unnatural' climatic occurrences were the result of undesirable human activity. From this it followed that the cure was to limit this undesirable activity regardless of the cost to society.

These aspects of climate change are of fundamental importance to the future prosperity of South Africa. In this report it is shown with a high degree of confidence that the multi-year variability of South African climate is directly related to solar activity. The postulated adverse climatic changes resulting from human activity, if present, are undetectable against this background and are therefore no cause for concern.

There is no evidence of changes in climate during the past century that can be attributed to unnatural causes. Nor are such changes likely to occur in future. The alarmist claims by climate change lobbyists are groundless.

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Abstract

Statistically significant 21-year periodicity is present concurrently in South African annual rainfall, river flow, flood peak maxima, groundwater levels, lake levels and the Southern Oscillation Index. This is directly related to the double sunspot cycle. The first years of the periodic sequences are characterised by sudden, regular and therefore predictable, reversals from sequences of well below average rainfall and river flow (droughts) that are suddenly broken by sequences of well above average events (floods). These reversals are directly related to corresponding six-fold increases in sunspot activity at this time. The two sunspot cycles that comprise the double sunspot cycle also have fundamentally different effects on the hydrometeorological responses.

Postulated climate changes resulting from human activity, if present, are undetectable against the background of natural variability. These observations are solidly based and will require a re-assessment of the claims in the climate change literature that variations in solar activity have minimal influence on the principal climatic processes.

Introduction

In 2001 the Intergovernmental Panel on Climate Change (IPCC) published its ***Summary for Policymakers*** (IPCC 2001). It defined climate change as any change in climate over time, whether due to natural variability or as the result of human activity. It defined radiative forcing as the influence of external factors on climate. These include natural factors such as changes in solar output or explosive volcanic activity. It continued with the statement that the characterisation of these climate forcing agents and their changes over time, is required to understand past climate changes in the context of natural variations in order to project what climate changes could lie ahead.

It is claimed that natural factors have made small contributions to radiative forcing over the past century. Reference is made to observed small oscillations due to the 11-year solar cycle. It was concluded that '*Mechanisms for the amplification of solar effects on climate have been proposed, but currently lack a rigorous theoretical* ***or observational*** *basis.* (Emphasis added).

From 2001 through to the end of 2005 serious drought conditions developed over most of the African subcontinent. Rivers were dry, dams were emptying and water restrictions were in force in many regions. On 9 November 2005 I issued the following flood alert.

> Exactly ten years ago, in November 1995, South Africa experienced severe, widespread floods that broke several years of severe drought. The conditions then were very similar to the present situation. We have already entered the turbulent period associated with the occurrence of the Sun's reversal of magnetic polarity. The tropical cyclone activity that includes Katrina, is a consequence of this activity.
>
> My prediction is that there is a better than 75% probability of widespread, flood-producing rainfall occurring between now and the end of April. The prediction is based solely on the assumption that the observed periodicity in flood-frequency analyses will continue.

Widespread, flood-producing rainfall commenced early in January 2006. By the end of February the soils were saturated and rivers were in flood. Nearly all the major dams in the summer rainfall area were full and water restrictions were lifted.

The length of the solar cycle during the last century was 10.4 years, not 11 years as erroneously stated in the IPCC publications. The commencement of the floods occurred 10.2 years after the commencement of the 1995 floods. Both flood events immediately preceded the sunspot minima. This and the other evidence detailed below demonstrates the unequivocal causal linkage between solar activity and the regular, predictable occurrence of drought-breaking, widespread, heavy rainfall events.

It is shown in this presentation that the IPCC statement regarding the minimal role of variations in solar activity on climate is seriously in error. The regular variations in solar activity are the dominant cause of climatic variability in the African subcontinent. Adverse climatic variations resulting from human activity are undetectable against this background.

It is demonstrated with a high degree of assurance that the claimed adverse effects of global warming will not pose a measurable threat to the natural environment or the prosperity of the people of South Africa. This in turn raises the fundamentally important question. Why was the causal linkage between solar activity and climatic responses that has been **observed, studied, confirmed and reported** for more than a century in South Africa, completely ignored in the IPCC studies? This question will be addressed in this report.

Time series analyses

The following passage is from the technical summary of Working Group 1: The Scientific Basis: Section D. ***The Simulation of the Climate System and its Changes*** of the IPCC report of 2001.

> This section bridges to the climate change of the future by describing the only tool that provides quantitative estimates of future climate changes, namely, numerical models…
>
> The complexity of the processes in the climate system prevents the use of extrapolation of past trends or statistical and other purely empirical techniques for projections…
>
> The degree to which the model can simulate the responses of the climate system hinges to a very large degree on the level of understanding of the physical, geophysical, chemical and biological processes that govern the climate system.

Unfortunately, **this procedure is fundamentally flawed**. The interest is in climate change. Climate in turn does not refer to an instant in time but to a period of time. For example, agricultural and water supply droughts have durations measured in years. The interest is therefore in the properties of future multi-year time series not in changes in mean conditions. Global climate models (GCMs) are inherently incapable of producing information in this format.

It is clear from the above extracts that the climate change researchers did not appreciate the fundamental difference between process theory, which they applied, and observation theory, which is the foundation of the applied sciences. A simple example is the biblical reference to Joseph’s prediction of seven years of plenty followed by seven years of famine. More than three thousand years ago the administrators in the ancient Egyptian civilisations were aware of this anomalous grouping of sequences of wet and dry years and the ability to predict future conditions, whereas the IPCC researchers maintained:

> The complexity of the processes in the climate system prevents the use of extrapolation of past trends or statistical and other purely empirical techniques for projections…

The fundamental need for accurate measurements of the flow in the Nile River in order to be able to predict future conditions, was obviously apparent thousands of years ago. In 641 AD - more than 1400 years ago - an architecturally attractive water level gauging structure was built on Rodda Island at Cairo. The record from the Rodda Nilometer is the longest available hydrological record in the world.

In the late 1940s the civil engineer R.E. Hurst (1948) analysed 1080 years of data from the Rodda Nilometer recorded during the period 641 to 1946, which he intended using to determine the required storage capacity of the proposed new Aswan High Dam. He found an unexplained anomaly in the data. He then analysed other long geophysical records, where he found the same anomaly. These were sediment deposits in lakes (2000 years), river flow (1080 years), tree rings (900 years), temperature (175 years), rainfall (121 years), sunspots and wheat prices. This anomaly became known as the Hurst phenomenon, or Hurst's Ghost.

It is important to note his use of proxy data from a variety of other climate-related processes in an attempt to quantify the numerical properties of the annual flow sequences in the Nile River. Even more important was Hurst's conclusion that the proxy data exhibited the same anomalous properties as river flow. Recently, some 50 years later, proxy tree ring data was used by climate change researchers as a basis for developing the critically important models for climate change scenarios. (IPCC 2001.) These have been the subject of severe criticism, but neither the climate change scientists nor their critics appear to have taken the trouble to examine the wealth of hydrological publications that describe the attempts of hydrologists to solve the problem during the period 1950 to 1970. A sense of frustration is evident in the many research papers published in the hydrological literature at that time. The following are some important examples that are relevant to the scientifically naïve views expressed in the IPCC publications.

Mandelbrot and Wallis (1968) introduced the terms 'Noah Effect' to describe the fact that extreme precipitation can be very extreme indeed, and 'Joseph Effect' to describe the fact that a long period of high or low precipitation can be extremely long. Yevjevich (1968) stated that attempts at long-range forecasts of water supply based entirely on meteorological processes had misdirected research and raised false expectations. Wallis and Matalas (1971) noted that there was a tendency for high flows to follow high flows and for low flows to follow low flows. This was referred to as hydrologic persistence. It was attributed to storage processes in the atmosphere or in the drainage basin, either surface or subsurface.

Yevjevich (1972) commented that one of the earliest deterministic methods used in hydrology was the application of the concept of almost-periodic series to various hydrological sequences in search for their hidden periodicities. However, their extrapolation as the prediction of future events represented one of the most spectacular failures of past hydrologic investigations. [My studies show that he was wrong.]

Wallis and O'Connell (1973) maintained that the presence or absence of long-term persistence could radically alter the expected value of reservoir design storage and hence the estimate of the firm yield. [I agree.] Finally, Klemes (1974) commented that ever since Hurst published his famous plots for some geophysical time series, the classical Hurst phenomenon continued to haunt statisticians and hydrologists, and that **attempts to derive theoretical explanations from the classical theory of stationary stochastic processes have failed**.

Note that although the cause of this anomalous behaviour must have been the result of perturbations in the climatic driving mechanisms, no attempts were made to establish this linkage. The simple reason was that there were no concurrent climatological measurements at the required space and time resolutions, and no adequate theory linking climatic perturbations directly with the observations. [I believe that my studies will lead to the eventual explanation of the Hurst phenomenon.]

It is ironical that fifty years ago civil engineers observed and reported anomalies in long, reliable hydrological records including rainfall and river flow. This caused them to examine proxy data where they found the same anomalies. Now, fifty years later climate change scientists have completely ignored both the wealth of hydrological data as well as the well-reported multiyear anomalies in the data. They have developed complex models of global climate based on proxy data that exhibits the same anomalous behaviour, to predict adverse changes in the hydrological processes, for which there is no believable evidence.

Historical perspective

There are many properties of annual rainfall sequences that have been observed in South Africa for a century or more that remain unresolved. The primary and most important property is whether or not there has been a change in the mean annual rainfall during the period of continuous records. This has been the subject of a number of reports of high-level commissions of enquiry appointed by the government of the day to examine the causes and possible amelioration measures of recurrent droughts. Whether or not the droughts were caused by a systematic reduction in rainfall over South Africa was the key issue.

In 1948, forty years before the establishment of the IPCC, the Department of Irrigation published a 160-page memoir by the civil engineer D.F. Kokot titled *An investigation into evidence bearing on recent climatic changes over southern Africa,* (Kokot 1948)**.** It contained 418 references, including reports by early travellers and missionaries. He found no evidence of a general decrease in rainfall or river flow, despite increases in carbon dioxide (CO_2) emissions. He concluded that there was no evidence of a linkage between CO_2 emissions and rainfall over South Africa.

The report of the Desert Encroachment Committee appointed by the Minister of Agriculture was published in 1951. (van der Merwe et al 1951). This was a thorough multidisciplinary report by a team of South Africa's leading scientists. They concluded that there was no evidence of a general decrease in the rainfall in South Africa that could be attributed to climate change.

In the mid-1970s, hydrologists in the South African Department of Water Affairs encountered the same problem that Hurst had observed 25 years earlier. There were far too many periods when restrictions had to be imposed on the water supply from the Vaal and other major rivers. It became clear that the reservoir capacity-yield model then in use in South Africa was deficient, and that this was probably due to assumptions regarding the river flow characteristics. A team of hydrologists was assembled to examine assumptions relating to the properties of the river flow sequences used in storage capacity-yield analyses. The mathematical models did not provide any insight, but graphical analyses showed that there was a very clear 20-year (later 21-year) periodicity in the data and that this was the cause of the difficulty. I instigated and headed the studies. The findings were published in 1978 in a Department of Water Affairs' technical report titled *Long range prediction of river flow – a preliminary assessment* (Alexander 1978). The graphs showed that there was a clear pattern in the accumulated departures from the record mean values and that these were approximately synchronous with sunspot activity. These were quite different from random deviations.

My research along these lines continued. In the Vaal River, the periodicity approached the 95% level of statistical significance required in many engineering applications. My paper *Floods, droughts and climate change* was published in the South African Journal of Science in August 1995. (Alexander 1995.) I detailed my analytical methods and also referred to the Hurst phenomenon. I concluded: *The acid test that will demonstrate whether or not the 20-year periodicity continues is at hand. If the drought is broken by widespread rainfall during the next two years it will surely be conclusive.*

Four months after the publication severe floods occurred over a wide area of southern Africa. Lives were lost and the drought was broken. The periodicity of flows in the Vaal River reached the 95% confidence level confirming my predictions and my model.

I was also the first person to report a sustained increase in the rainfall over South Africa based on a study of 7141 years of district rainfall data. Why have no climatologists acknowledged this undeniable increase? Surely this is good news. This denial of the beneficial consequences of global warming has become a trademark of climate change scientists.

Clash of theories

As shown above, observation theory based on numerical measurements is as old as civilisation itself. The design of every structure exposed to the forces of nature and every storage dam on a river designed to supply water, is based on an analysis of recorded data. Process theory, which is the study of the processes that produce the rainfall and therefore river flow, does not feature in the design of these structures anywhere in the world, from ancient civilisations through to the present day.

In contrast, climatology is a young science and is based on abstract process theory supported by limited measurements. Traditionally, one of the main thrusts of climatology has been the study of climate on a geological time scale extending many thousands of years back in time. It is therefore understandable that climatologists interested in climate change chose to use centuries-old proxy data such as data derived from ice cores and tree rings, to develop linkages between climate and the terrestrial consequences.

This jump from atmospheric processes to the hydrological consequences completely ignores observation theory applied to the wealth of readily available data. Hydrologists have been aware of climate-related anomalies in the hydrological data for at least half a century. No attempts were made by climate change scientists to address the causes of these anomalies for the simple reason that they were not aware of them.

Process theory is fundamentally incapable of producing predictions in a numerical format required for subsequent analyses. The net result is that climate change scientists have been unable to produce any believable evidence to support their alarmist claims. This has a ripple effect. Hydrologists are unable to evaluate and quantify the changes. Economists are unable to determine the costs and benefits of preventive or adaptation measures. Political decision makers are unable to make rational decisions. The whole system fails.

Levels of believability

In law there are generally two levels of proof – balance of probabilities and beyond reasonable doubt. The seriousness of the whole climate change issue requires numerical proof at the beyond reasonable doubt level. It must be obvious to any informed enquirer that the IPCC claims would be beyond reasonable doubt if it could be shown that there were undeniable, progressive, adverse changes in rainfall and river flow during historical times that could reasonably be associated with global warming. It is nowhere near meeting this requirement.

It is axiomatic that any predictions of future climate change require a sound numerical understanding of current conditions as the point of departure. However this is by no means a simple exercise. Climate is never constant on any time scale from hours through to thousands of years. As the end product of climate change research has to be in numerical terms, the logical basis for evaluating changes is from the commencement of the period of measurement of the consequences of interest. Note that it is the consequences such as changes in rainfall and river flow that are important, not changes in the atmospheric and oceanic processes that produce them. **Proof of global warming is not proof of the postulated undesirable consequences**.

Climate-related hydrological concerns

Climate change studies concentrate on postulated changes in the mean values. However it is the variability of the hydrological processes that is the fundamental property of interest. For example, if the flow in a river is constant there is no need to build storage dams, and the total flow in the river is available for use. The greater the year-to-year variability, the greater the volume of storage required for a specified yield. This in turn exposes the stored water to evaporation losses. The highly variable flows in South African rivers result in the need for large capacity storage dams and consequent high evaporation losses. These losses account for about 25% reduction in the potential yield of South African dams.

Outputs of climate change scenarios go no further than postulating changes in the mean values. For example, the claim that the future climate over a region will be drier and warmer than at present. Even the ancient Egyptians were well aware that it was not the average annual flows in the Nile River that were important but the sequences of years with below average flows. This was described as the Joseph Effect in the early hydrological literature. (Mandelbrot and Wallis 1968.) Global climate models are incapable of providing this essential information.

Engineering hydrology

Engineering hydrology is an applied science based on observation theory. While the linkages between solar activity and the hydrometeorological responses have been known for more than a century, it has never been necessary to quantify them. The principal reason is that it has not been possible to determine the statistical properties of the relationships required for engineering applications directly from those of the atmospheric processes or solar activity. The situation has now changed.

The water resources of South Africa and in many other semiarid regions of the world are rapidly approaching the limits of exploitation. The Intergovernmental Panel on Climate Change (IPCC) in its Summary for Policymakers (IPCC 2001), Tyson and Gatebe (2001), Schulze, Meigh and Horan (2001) and New (2002) predicted that global warming resulting from increasing greenhouse gas emissions, will have serious, adverse effects on water supplies, and that floods and droughts will increase in magnitude and frequency. It appears that little credence was given to the role of variations in solar activity and the poleward redistribution of solar energy on climate variability. South African experience demonstrated that these are the dominant causes of the variability and extremes in the hydrometeorological processes.

There was therefore an urgent need to quantify the effects of variation in solar activity and the redistribution of solar energy on the variability of rainfall, river flow, floods and droughts in South Africa, and possibly elsewhere in the world where similar conditions prevail.

Database

Conventional sunspot cycles were used as an indicator of solar activity. The following data are from website information distributed by the World Data Centre for the Sunspot Index (2005). There were eight complete cycles during the past century. These commenced with the sunspot minimum that occurred in June1913, and ended with the sunspot minimum that occurred in March 1996. The lengths of the cycles were 10, 10, 11, 10, 10, 12, 10 and 10 years, with a mean of 10.4 years. These values are within a narrow range of between 10 (minimum) and 12 (maximum) years. A corresponding increase in solar activity during the past century is reflected in the increase in the numbers of sunspots per cycle, commencing with the cycle that started in 1913. Alternating cycles are identified by negative values. The sunspot numbers per cycle were +442, -410, +605, -757, +950, -705, +829 and –785. The maximum was more than twice that of the minimum that occurred only three cycles earlier.

The lengths of the corresponding double sunspot cycles were 20, 21, 22 and 20 years with a mean of 20.8 years, a minimum of 20 years and a maximum of 22 years. The average number of sunspots in the alternate cycles that make up the double cycles were +706 and –664, demonstrating a meaningful difference in sunspot activity in the alternating cycles. As will be seen, the alternating sunspot cycles have appreciably different effects on the hydrometeorological processes.

It will later be demonstrated that it is not the annual sunspot densities that are important in identifying the relationship, but the rate of change in the densities. This is not apparent in the conventional graphs of the sunspot cycles where all numbers have positive values. The sunspot numbers in the alternating sunspot cycles were therefore given negative values, and an arbitrary graph origin of -200 was used for convenience in order to present all values as positive numbers. This is a requirement for statistical analyses where logarithms are employed. (Alexander 2002b). These are graphical datum changes and do not affect the interpretations.

The largest and most comprehensive hydrometeorological database yet assembled in South Africa was studied. It consisted of just less than 18 000 observations from 200 data sets and eight different hydrometeorological processes. Details are given in Table 1.

Table 1. Database used in the analyses			
Set	Process	Sites	Observations
1	Water surface evaporation	20	1 180
2	Concurrent rainfall	20	1 180
3	District rainfall	93	7 141
4	River flow	28	1 877
5	Flood peak maxima	17	1 235
6	Groundwater	4	312
7	Southern oscillation index	1	114
8	Regional widespread rainfall	15	6 171
	TOTAL	198	17 975

The sites were selected on the basis of their geographical representativeness and long, reliable records. All except two of the records (Southern Oscillation Index and Zambezi River flow) were extracted from official databases operated by the South African Weather Service and the Department of Water Affairs and Forestry. Other than minor patching of missing data, the data were not smoothed, filtered or in any way manipulated before or during the analyses. This is an essential requirement for hydrological time series analyses. The use of annual data avoids the need to accommodate seasonal changes.

The data sets analysed by Tyson (1987) and Bredenkamp (2000) are not included in the above details.

Methodology

The emphasis was on simple arithmetical and graphical interpretations rather than mathematical interpretations. The reasons were that mathematical analyses such as harmonic and spectral analysis methods suppress the important, sudden changes that are present in hydrometeorological time series, and may also introduce oscillatory behaviour that is not present in the data.

Standard serial correlation analyses were sufficient to identify statistically significant serial dependence and/or cyclical behaviour should they be present. This procedure followed the standard time series analysis methods that require that the processes be identified graphically in the first instance, and only subsequently be described mathematically. (Chatfield 1982). Additional information on the methodology developed by the author for hydrological time series analyses, is detailed in Alexander (1994, 1995a and 1997).

Trend analysis

Conventional statistical trend analyses could not be performed in the presence of the large periodic variations in the data described below. However, simple arithmetical and graphical analyses demonstrated increases in rainfall in 75 of the 81 rainfall districts with complete records, totalling 9% for South Africa as a whole for the 78-

year period 1921 to 1999. Forty-two districts had increases of 10% or more, 12 districts had increases of more than 20%, and four districts had increases of more than 40%. There was also an increase in the numbers of widespread, heavy rainfall events during the latter half of the past century.

There were also increases in open water surface evaporation observed in 14 of the 19 accepted data sets studied. No trends were discernible in any of the other processes studied. If present, they were overwhelmed by the natural variability of these processes.

Numerical comparison

The next aspect studied is illustrated in Table 2, which lists the annual flows in the Vaal River at Vaal Dam as percentages of the mean annual runoff at the site. Vaal Dam is the major source of water for South Africa's largest metropolitan, industrial and mining region. This is the most analysed hydrological record in South Africa. The full period reversals (heavy horizontal lines) refer to the years when the sudden reversals from low flow sequences to high flow sequences occurred. These identified the commencement of the 21-year periods. [These are not exactly 21-years apart.] The light horizontal lines identify the commencement of the mid-period reversals.

TABLE 2. VAAL RIVER - ANNUAL FLOW RECORD 1923/24 TO 1995/96

Expressed as percentages of the mean, showing the mid-period and full period sudden reversals from drought sequences to flood sequences.

Year	Inflow	Year	Inflow	Year	Inflow	Year	Inflow
23/24	39	43/44	353	63/64	58	83/84	79
24/25	246	44/45	87	64/65	149	84/85	30
25/26	42	45/46	66	65/66	27	85/86	36
26/27	66	46/47	58	66/67	175	86/87	46
27/28	44	47/48	57	67/68	31	87/88	208
28/29	83	48/49	33	68/69	35	88/89	165
29/30	142	49/50	100	69/70	60	89/90	65
30/31	40	50/51	33	70/71	52	90/91	59
31/32	36	51/52	60	71/72	102	91/92	13
32/33	24	52/53	100	72/73	23	92/93	26
33/34	170	53/54	45	73/74	112	93/94	92
34/35	131	54/55	181	74/75	295	94/95	17
35/36	87	55/56	80	75/76	247	95/96	464
36/37	225	56/57	277	76/77	123	96/97	N/A
37/38	59	57/58	188	77/78	122	97/98	N/A
38/39	202	58/59	69	78/79	31	98/99	N/A
39/40	112	59/60	75	79/80	63		
40/41	131	60/61	105	80/81	62		
41/42	54	61/62	50	81/82	19		
42/43	185	62/63	68	82/83	12		

The reversals in the flows in the Vaal River from drought sequences to flood sequences evident in Table 2 correspond closely with similar reversals in sunspot density. This is evident in Table 3. In all but one sequence (Vaal River 1965/66, data not available), the three-year totals after the minima of both river flow and sunspot numbers, are substantially greater than the three-year totals before the minima. This information demonstrates the close association between major variations in river flow and corresponding variations in sunspot activity, with a high degree of confidence.

Table 3. Comparison of sudden changes in the annual flows in the Vaal River with corresponding sudden changes in sunspot numbers

Three-year totals of flows in Vaal River (% of record mean)			Three-year totals associated with the corresponding sunspot minimum		
Minimum year	Three previous years	Three subsequent years	Sunspot minimum	Three lowest years	Three subsequent years
1932/33	100	388	1933	25	250
1941/42	297	625	1944	56	277
1953/54	205	538	1954	50	370
1965/66	234	241	1964	53	247
1972/73	177	654	1975	73	275
1986/87	112	438	1986	60	400
1994/95	135	464+	1996	48	277
Average	180	478	Average	52	300

There are several interesting features in this table. There is an almost three-fold, sudden increase in the annual flows in the Vaal River from the three previous years to the three subsequent years. This is directly associated with a six-fold increase in sunspot numbers. The second important point is the consistency in the range of sunspot numbers before and after the reversal. The totals for the three prior years varied between 25 and 60, and the totals of the three immediately subsequent years varied between 250 and 400. It is very clear that these are systematic changes associated with the sunspot minima, and are not random events.

This relationship exists despite the long and complex energy path starting at the Sun and ending in the river flow that enters Vaal Dam. The only residual energy is the potential energy, which is a function of the elevation of the water mass above sea-level. This residual energy has its origin in solar activity; followed by the arrival on the Earth's atmosphere, continents and oceans; followed by the poleward movement of the energy through complex atmospheric and oceanic processes; followed by the systems that produce the rainfall; and finally by the complex rainfall-runoff processes. The survival of the periodic signals on its own demonstrates a strong and unequivocal relationship between variation in solar activity and the corresponding variation in climatic responses.

Graphical comparison

The next issue is the nature of the solar-induced periodicity of the hydrometeorological processes.

Fig. 1 shows graphical comparisons of the properties of the double sunspot cycle with those of the Vaal River. This follows the method developed by Alexander (1978) and successfully used to predict the climate reversal from drought to flood sequences that occurred in 1995. (Alexander 1995).

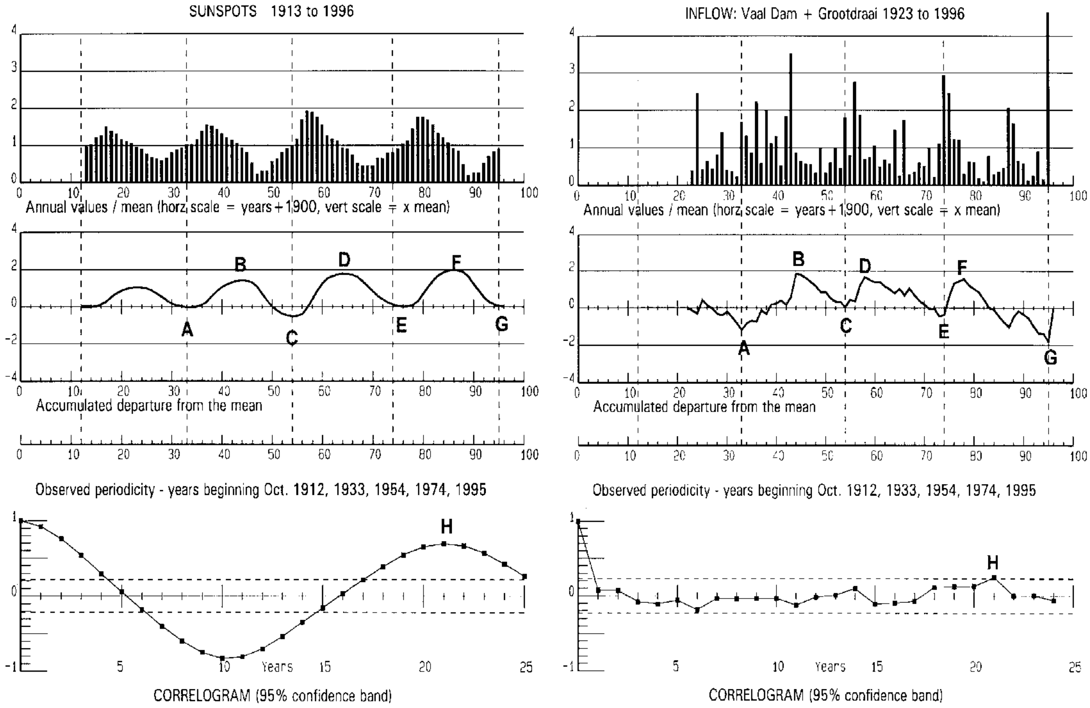

Figure 1. Comparison of the characteristics of annual sunspot densities with corresponding characteristics of the annual flows in the Vaal River.

A reference datum value of –200 was used in the sunspot data in order to accommodate the negative values. This has no effect on the interpretations. The top panels are the conventional dimensionless histograms, where all values are expressed as multiples of the record mean values. While the cyclicity is apparent in the sunspot panel it is not recognisable in the river flow. The river flow histogram shows the high degree of asymmetry about the mean value with many more values less than the mean value than above it. This is typical of river flow data in dry climates.

The most informative graphical presentations are those in the second panels, which show the accumulated departures from the record mean values. These are obtained by subtracting the mean values (1.0) from each of the values in the histogram. Some of the values will be negative. These are accumulated one at a time and the sum plotted.

An increase in the accumulated departures of the sunspot numbers during the period of record is immediately apparent. The maximum negative departures occured at the start of the 21-year periods, identified as (A), (C), (E) and (G).

The comparison with that of the flow in the Vaal River is very instructive. The reversals at points (A), (C), (E) and (G) are virtually identical with the corresponding reversals in the sunspot data. They occurred during the hydrological years beginning October 1933, 1954, 1974, and 1995. The rising limbs A-B, C-D and E-F are sequences of years where the inflows were greater than the mean value. The falling limbs B-C, D-E, and F-G are sequences where the inflows were less than the mean value. These alternating sequences were reported in the early hydrological literature where they were referred to as the Joseph effect, after Joseph's biblical prophecy. (Mandelbrot and Wallis 1968).

The third panels are the correlograms. This is a standard calculation procedure in time series analyses. The statistically significant cyclicity in the sunspot data is clearly apparent. The 95% confidence limits are ± 0.22. The minimum and maximum (H) autocorrelation coefficients occur respectively at 10 (-0.83) and 21 (+0.70) years, which are well in excess of the 95% confidence limits.

The statistically significant cyclicity in the sunspot cycles is no longer present in the correlogram of the annual flows in the Vaal River, where the residual coefficients indicate random noise. The only, but very important, residual serial correlation, is the statistically significant 21-year periodicity. This is identified at (H) in the bottom panel of the figure.

21-year periodicity in hydrometeorological data

Table 4 shows the presence of 21-year concurrent periodicity in South African hydrometeorological data. The degree of statistical significance is dependent on the length of the record as well as the magnitude and nature of the variability about the mean. The periodicity is almost certainly present in all hydrometeorological data series, other than evaporation, but has not yet reached a high level of statistical significance at some of the sites.

Table 4. Presence of 21-year concurrent periodicity in hydrometeorological data

Process	Nr of sites	Record years	Periodicity			
			95%	Present	None	Not determinable
Evaporation	20	1 180	0	0	20	0
Rainfall	93	7 141	18	67	8	0
River flow	28	1 877	7	12	5	4
Flood peak maxima	17	1 235	4	7	2	4

While the reversals are a characteristic of the start of the periods, the periodicity refers to the whole spectrum of values. For example, a significant correlation exists between all the fifth values after the commencement of the periods, all the ninth values, and so on. This relationship is stronger than the relationship between successive values in the hydrometeorological data where no statistically significant serial correlation exists. (See the plot of the first year in the correlogram for the Vaal River in Fig. 1.)

Nature of the periodicity

Fig. 2 illustrates the nature of the periodicity in river flow at a number of representative sites in South Africa. The procedure used for each site was to extract the data in 20-year sequences starting in October of the following years: 1912, 1933, 1954, 1974 and 1995. Then the average values for each year of the sequence divided by the record mean annual runoff (MAR), were determined and plotted. The reference period used for calculating the MAR was that from 1954 to 1974 as it was the only period that was common to all data sets. The selection of a reference period does not affect the results. This procedure was repeated for the other sites. The rainfall and flood peaks exhibited similar characteristics, although the rainfall amplitudes were less and the flood peak amplitudes were greater than those of river flow. The diagrammatic double sunspot cycle is included in the figure for ease of comparison.

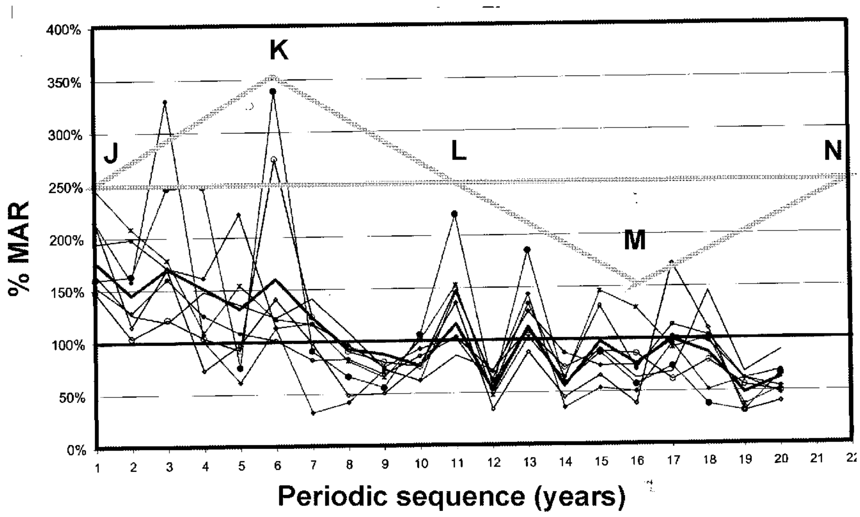

Figure 2. Characteristics of the periodic sequences of river flow at representative dam sites. The double sunspot cycle is diagrammatically superimposed.

While there is a large scatter in the plotted results, the general trend is clear and several conclusions can be drawn from it. Major flood events are associated with the first half of the first sunspot cycle, (J-K). This is the sub-period when the **rate of increase** in sunspot density is greatest, (see Table 3 above), and is associated with global atmospheric and oceanic turbulence at this time. This in turn generates the processes that produce heavy, widespread rainfall events that generate river flow.

In contrast, sunspot density decreases during the second half of the first cycle (K-L). This is a quiescent sub-period with reduced turbulence in the poleward energy distribution process, and consequent absence of high rainfall events that generate river flow. Droughts occur as a result of the absence of these events.

The characteristics of the second of the two sunspot cycles (L-M-N) are very different from those of the first cycle (J-K-L). Fewer heavy rainfall events occur. Droughts become increasingly prevalent during this cycle. It is postulated that this is the consequence of the differences in solar magnetic polarity between the two cycles as well as the lesser sunspot density.

There is also a clear, diminishing, annual oscillatory pattern during the beginning of the second sunspot cycle (L-M) that is not present in the greater scatter during the first cycle. No possible causes can be offered.

Further confirmation

Further confirmation of the linkage between the rate of increase in sunspot density and rainfall over South Africa as a whole is shown in Table 5, which shows the relationship between the months during which the maximum rainfall occurred and the corresponding years in which the sunspot minima occurred. The lag is the difference in years when the sunspot minima are used to predict the rainfall maxima. The lower panel is a repeat of the upper panel, using the flood peak maxima observed in the Mkomazi River, south of Durban.

Table 5. Comparison of ranked maximum values with sunspot minima				
	South African rainfall		Sunspot minima	
Rank	Month	mm	Year	Lag (years)
1	Mar 1925	211	1923	+2
2	Jan 1974	149	1976	-2
3	Feb 1939	148	1933	+6
4	Feb 1988	145	1986	+2
5	Jan 1923	138	1923	0
6	Jan 1976	136	1976	0
7	Feb 1955	132	1954	+1
8	Jan 1958	130	1954	+4
Ranked flood peak maxima in the Mkomazi River				
	Flood maxima		Sunspot minima	
Rank	Year	m^3/s	Year	Lag (years)
1	Mar 1856	7 000	1856	0
2	Mar 1925	6 260	1923	+2
3	May 1959	6 200	1954	+5
4	? 1868	6 130	1867	+1
5	Mar 1976	2 140	1974	+2

The 1856 peak was concurrent with the flood peak in the Mgeni River, where floodwaters flowed across Durban and into Durban harbour. These floods occurred in March 1856. The maximum recorded flood engraved on the buttress of the Georges V Bridge built in 1760 across the Loire River in Orleans, France occurred in June 1856. The sunspot minimum occurred in December 1855. (World Data Centre for the Sunspot Index 2005). This correspondence in time (months) and space (hemispheres apart) is far too great to be coincidental.

Six of the eight rainfall events and four of the five flood peak maxima occurred within two years of the sunspot minima. This confirms that these extreme events are sensibly synchronous with the reversals in sunspot density associated with the sunspot minima as shown in Table 2.

It is also important to note that these maxima were recorded 80 years ago (rainfall) and 149 years ago (Mkomazi floods), and that there is no evidence of an increase in time that could be associated with global warming. Historical observations in several other rivers confirm that the floods in the mid-1800s remain the highest on record.

Alternating wet and dry sub-periods

Analyses showed that the rainfall and river flow during the first half-period (first sunspot cycle) are appreciably higher than the second half-period. For example, for the first ten years of the period, the average of the maximum annual river flow values for all sites analysed was 675% of the record mean values compared with the average of the following ten years of only 380% of the record mean values. This is probably associated with the sign of the Sun's magnetic polarity. Other analyses not reported here showed that the high values in the first half-period are the result of widespread, heavy rainfall events, while the low values in the second half-period are the consequence of the absence of these events.

Tyson (1987) provided evidence supporting the presence of alternating sequences of years with high and low rainfall over large regions of South Africa. He noted the oscillatory nature of the data and although he was unable to trace its cause. He concluded that its physical reality was considerable in South Africa and in other countries. He noted that the 11-year solar cycle was mentioned in the literature but he did not discuss it further.

Bredenkamp (2000) studied groundwater resources. He used the cumulative departure method as his principal tool, for which he developed a mathematical relationship. He demonstrated the presence of wet and dry sequences from 1919 through to 1992 based on water level observations at Lake Mzingazi; discharge from the Uitenhage springs corrected for abstractions; water levels at Lake St Lucia; and groundwater levels at the Wondergat sinkhole in a large dolomitic formation. These all have high storage/input ratios that smooth out the short-term fluctuations.

Table 5 is a combination of the independent observations by Tyson (1987) and Bredenkamp (2000), each relating to different climatic processes and different analytical methodologies, and a comparison with sunspot cycles. The first and most important observation is the presence of alternating sequences of wet and dry years, and the corresponding alternating sequences of sunspot cycles. While the comparative years are not precise, there can be no doubt at all that a meaningful relationship exists with sunspot cyclicity.

Table 5. Wet and dry sequences				
Years	Wet/dry	Length of sequence		Sunspot cycles
		Wet	Dry	
Bredenkamp: Mzimgazi + St Lucia + Uitenhage + Wondergat				
1919-24	Wet	5		1913-22
1925-29	Dry		4	1923-32
1930-39	Wet	9		1933-43
1941-53	Dry		12	1944-53
1955-62	Wet	7		1954-63
1965-71	Dry		6	1964-75
1972-78	Wet	6		1976-85
1980-83	Dry		3	-do-
1984-90	Wet	6		
Tyson: South African rainfall				
1905-15	Dry		10	1901-12
1916-24	Wet	8		1913-22
1925-32	Dry		7	1923-32
1933-43	Wet	10		1933-43
1944-52	Dry		8	1944-53
1953-61	Wet	8		1954-63
1962-70	Dry		8	1964-75
1971-80	Wet	9		1976-85

Compare the lengths of the sequences of wet and dry years with the biblical seven years of plenty followed by seven years of famine. The ancient Egyptians were well aware of these alternating sequences in the annual flows of the life-giving Nile River.

Mathematical modelling

The final stage was the development of a mathematical simulation model for water resource development and management applications that accommodates the characteristics described in this paper. There was no need to invoke linkages with solar activity. Nor was it necessary to include the postulated adverse consequences of global warming, such as increases in floods and droughts and threats to water supplies, for which there was no evidence. The methodology developed by the author is described in Alexander. (1994, 1997).

Interpretation

The following view was expressed in the IPCC's Summary for Policymakers (IPCC 2001):

> Since the late 1970s, satellite instruments have observed small oscillations due to the 11-year solar cycle. Mechanisms for the amplification of solar effects on climate have been proposed, but currently lack a rigorous theoretical or observational basis.

In 1889 Hutchins published a very perceptive and well-documented linkage between solar activity and climate-related responses. (Hutchins 1889). This linkage was repudiated by many eminent solar physicists, who for the past hundred years have maintained, and still maintain, that these correlations lack causal mechanisms supported by high quality data. In this report a causal linkage is demonstrated with a high degree of confidence based on a detailed study of a very large climate-related database.

Hopefully, the information provided here will assist solar physicists identify the specific characteristics of the solar processes that cause these climatic features that were noted and documented in South Africa more than a hundred years ago, and on several occasions since then.

Conclusions

The following conclusions are based on the three-year study of a very large (18 000 observations) hydrometeorological database.

There is an unambiguous, regular and therefore predictable, statistically significant (95% level), 21-year periodicity in South African annual rainfall, river flow, flood peak maxima, groundwater levels and lake levels.

This periodicity is directly related to, and concurrent with, the double sunspot cycle.

The single, 11-year sunspot cycle is not statistically evident in the serial correlation analyses. The reason is that the alternating cycles have different characteristics. This explains why climate change researchers were unable to detect climate change characteristics that corresponded with the sunspot cycle. They should have searched for linkages with the double sunspot cycle.

The commencement of the responses to the double and single sunspot cycles are characterised by sudden reversals from low rainfall and river flow (drought) conditions to conditions of high rainfall and floods.

There is a direct correspondence between these reversals and sudden increases in annual sunspot numbers and reversals of solar magnetic polarity that occur at the time of the sunspot minima.

The abrupt rate of increase in solar activity also causes abrupt increases in the poleward redistribution of solar energy, which in turn results in increased frequency and magnitude of the widespread, heavy rainfall-producing systems. Quiescent periods have the opposite effect.

The responses to the two sunspot cycles that comprise the double sunspot cycle are fundamentally different. The sequences of rainfall, river flow, floods, lake and groundwater levels associated with the first cycle are appreciably higher than those of the second cycle. These alternating 'wet' and 'dry' sequences are well reported in the hydrological literature, but their relationship with sunspot cycles was not investigated prior to this study.

The general view of many climatologists and solar physicists that variations in solar activity are too small to account for observed variations in climate will have to be reviewed. Scientists who hold these views should also be aware that it is essential that the linkages between solar activity and climatic responses described in this report be incorporated in any global climate model used for predicting the influence of the accumulation of greenhouse gas emissions, if it is to produce verifiable results for practical applications. (Alexander 2002a, 2004).

Many other properties can be identified in hydrometeorological time series analyses that could provide valuable insights into the nature and quantification of the linkages between solar activity and the hydrometeorological responses.

Final confirmation

At the risk of oversimplification, this is the route that climatologists have followed in their long-term climate predictions. They noted the concurrent linkage between sea surface temperatures (SSTs) in the Pacific Ocean (El Niño and La Niña) and South African climate (dry and wet conditions respectively) and assumed that there was a **causal** linkage between the SSTs and our climate.

As long ago as in 1995 at the international IGBP conference here in Pretoria after I presented my ***Floods, droughts and climate change*** study, I asked the question '*What causes El Niño?* I received the joking response that if I could answer that question I might qualify for the Nobel Prize. Well, I can now answer that question. It is the direct consequence of changes in solar magnetic polarity. The occurrences during the past two months (January and February 2006), have provided the proof that I needed.

In a number of my memos and publications I demonstrated an undeniable linkage between changes in solar magnetic polarity and concurrent changes in South African rainfall and river flow. The strongest, and scientifically undeniable linkage, is that between reversals in solar magnetic polarity of which sunspot minima are a measurable manifestation, and the concurrent, sudden reversals from drought to flood sequences that started in December. The sunspot minimum that identifies the end of the 23rd sunspot cycle has just occurred.

But what about La Niña?

In my Flood Alert distributed on 9 November last year I wrote:

> Exactly ten years ago, in November 1995, South Africa experienced severe, widespread floods that broke several years of severe drought. The conditions then were very similar to the present situation. We have already entered the turbulent period associated with the occurrence of the Sun's reversal of magnetic polarity. The tropical cyclone activity that includes Katrina, is a consequence of this activity.
>
> My prediction (not forecast) is that there is a better than 75% probability of widespread, flood-producing rainfall occurring between now and the end of April. Please note that there is a 25% probability that this will **not** happen. This order of accuracy is much the same as the daily weather forecasts.
>
> The prediction is based solely on the assumption that the observed periodicity in flood-frequency analyses will continue.

I received responses to my flood alert from three experienced climatologists who are on my distribution list, to the effect that floods were unlikely. As one of them commented '*By ignoring current conditions, you are wasting your time. Pacific sub-surface temperatures are only slightly below normal in the 100-200 m layer'*. This response is very important and I am grateful for it, as it proves the point that I am about to make.

This comment shows that climatologists (in general) assume that there is a **causal linkage** between the Pacific sea surface temperatures and South African climate. However the La Niña phenomenon only commenced developing a month after my flood alert and concurrent with the commencement of the floods.

All three conditions developed simultaneously: the commencement of La Niña; the commencement of the floods; and the solar magnetic reversal. These are not instantaneous phenomena like switching on a light but develop over a short period of time (weeks, or months in some cases). It now becomes obvious that the floods were not caused by Pacific sea surface temperatures (La Niña), but that the floods **and** La Niña were both caused by regular, and therefore predictable, changes in solar magnetic activity.

Furthermore, my successful prediction of imminent floods demonstrates beyond all doubt that my analytical methods, based on observation theory applied to a very large and comprehensive hydrometeorological database, are superior to the mathematical global climate models based on process theory. There can be no doubt about this.

Where does this leave climate change theory?

Climate change theory rests heavily on mathematical models of global climate, which in turn are based on unprovable process theory. These models do not accommodate the undeniable effects of solar magnetic polarity and are therefore untrustworthy. This is illustrated by the inability of these models to provide provable evidence of their reliability when replicating real world processes.

My analysis of South African rainfall data shows that rainfall has increased, not decreased. It will continue to increase as long as the causative mechanisms remain unchanged. The global climate model is clearly unreliable and the outputs no more than speculative.

These aspects of climate change are of fundamental importance to the future prosperity of South Africa. In this report it is shown with a high degree of confidence that the multi-year variability of South African climate is directly related to solar activity. The postulated adverse climatic changes resulting from human activity, if present, are undetectable against this background and are therefore no cause for concern.

There is no evidence of changes in climate during the past century that can be attributed to unnatural causes. **Nor are such changes likely to occur in future. The alarmist claims by climate change lobbyists are groundless**.

Verification studies

The full data set in computer-readable format is available on request to those who would like to verify the conclusions or to carry out further studies along these lines. The information includes station reference data, which allows verification from the official authorities that supplied the information. Other than minor patching of missing data, the data were not smoothed, filtered or otherwise manipulated in any way before or during the analyses. The calculations were simple can be replicated without difficulty. No mathematical models were used in the analyses.

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