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WATER RESOURCE AND FLOOD STUDIES

TECHNICAL REPORT

A critical assessment of current climate change science

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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.

Biblical prophecies and modern predictions

... were all the fountains of the deeper broken up, and the windows of heaven were opened. And the rain was upon the earth 40 days and 40 nights. Genesis, 6, 11-12

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Behold, there came seven years of great plenty throughout the land of Egypt - and there shall arise after them seven years of famine. Genesis, 41, 29-30

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The yellow line rising steeply to a maximum and then falling away gradually to a minimum is the sunspot curve - a curve which ought to be graven on the mind of every man and woman in South Africa. (Hutchins 1889.)

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At the beginning of the present century, the famous astronomer, Sir Norman Lockyer, wrote that one of the foremost achievements of the new century would be to forecast well in advance the incidence of famine in India or drought in Australia by means of analyses of sun-spot spectra. (From the report of the Commission of Enquiry into Water Matters, 1970.)

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The classical attitude, viz. that drought is purely a chance occurrence in the climatic history of the country does not appear to be correct. In an objective approach the possible influence exerted by fluctuations in the sun's radiant energy on the incidence of drought is stressed. Some of South Africa's most severe and prolonged droughts of the nineteenth and twentieth centuries have without doubt coincided with troughs of minimum sun-spot activity. The sun thus appears to be either directly or indirectly responsible for abnormal weather. As the exact mechanism is not yet clear, <u>research in this field should evidently receive earnest attention</u>. [My emphasis.] (From the report of the Commission of Enquiry into Water Matters, 1970.)

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Since the late 1970s, satellite instruments have observed small oscillations due to the 11-year cycle. Mechanisms for the amplification of solar effects on climate have been proposed, but currently lack a rigorous theoretical <u>or observational basis</u>. [My emphasis.] (IPCC 2001).

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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. (Alexander 2006)

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1. Introduction

I fully appreciate that the conclusions reached in this report undermine the very foundations of climate change science and will almost certainly be challenged. They are nevertheless solidly based on observation theory applied to a wealth of climate-related data using methods that are in daily use by civil engineers and others in the applied sciences.

I believe that I have a public duty to present my views based on long experience and studies on whether or not there is any meaningful evidence of unnatural climate change in my principal fields of interest – water resources, floods, droughts, climate-related disasters, agriculture and the natural environment, and be available for discussions.

In this report I am severely critical of the alarmist claims relating to postulated adverse effects of global warming. This will invite the standard response that I am either ignorant or uncaring whereas it is precisely the opposite. My knowledge, long experience and recent studies lead to no other conclusion. I believe that I have a greater general knowledge and experience at the interfaces between the natural and applied sciences, as well as between national welfare and the political decision making process, than most readers of this report.

This report is written in non-technical language so that it reaches as wide an audience as possible. Passages that require some scientific knowledge can be skipped if they are not understood. They are described in detail in my comprehensive report ***An assessment of the likely consequences of global warming on the climate of South Africa*** now in the final stages of production, as well as in my other publications on this subject that are listed in the references.

Since the beginning of this year (2006), widespread floods and other climatic extremes have occurred in several regions of the world. The ever-opportunistic climate change scientists are already claiming this as evidence of global warming caused by human activities. The very thought that human beings could influence global climate on this scale does not seem to bother them.

As I demonstrate in this report, this sudden reversal from several years of drought to flood conditions has nothing to do with human influences. It is directly the result of regular variations in solar activity. This synchronous linkage has been known and described in the scientific literature for more than 100 years but has been denied in the publications of the IPCC, which is considered by many governments as being the ultimate authority on this subject.

If this was a simple difference of opinion, it could be safely left to history to determine whether variations in solar activity or human activities are the principal cause of undesirable climate changes. However, climate change scientists have succeeded in persuading many governments that drastic and very costly measures should be implemented as a matter of urgency to control global warming, which in turn is postulated to have a wide range of undesirable consequences.

2. Consequences of control measures

Pause for a while and consider the probable consequences of the proposed control measures on the welfare of the peoples of the African continent with their precarious economies and unstable governments.

South Africa and many other countries with dry climates are approaching the limits of their conventional water resources. The most promising source of supplementary supplies is seawater desalination. This will require the use of readily available coal to provide the large energy requirements for both desalination and for pumping the water from the coast to the interior. This will not be an option if the use of coal is banned. The result will be an increase in water shortages with all its socio-economic consequences.

Another consideration is that African subsistence farmers apply widespread veld-burning practices during the autumn and winter months to accelerate the growth of spring grazing for livestock. This produces large volumes of undesirable carbon dioxide (CO_2) emissions and smoke. These stretch through the atmosphere across the surrounding oceans. They are readily visible on satellite images.

The proposed measures to limit reliance on coal for power generation and future seawater desalination, as well as the inevitable follow-up by international environmental organisations to limit subsistence farmers' veld-burning practices, can only have one outcome – a decrease in national and individual prosperity for tens of millions of people on the African continent. The consequences will be an increase in poverty with accompanying increase in malnutrition and disease. Together, these will result in increased threats to economic and political stability of many African nations. These are very serious issues.

But what if these measures are implemented and it is subsequently found that the climate change theory on which they were based is unfounded? Consider all the economic and political consequences, including the irreversible damage to the public trust in science and scientists. What is the risk of this happening? As I demonstrate below, it is close to certainty. Surely, these are very important considerations that should be of great concern to the governments that propose implementing the costly measures to control the emissions of undesirable greenhouse gasses into the atmosphere.

3. My interest

This report is part of my wider, comprehensive studies that will be described in my 600+ page technical report titled ***An assessment of the likely consequences of global warming on the climate of South Africa*** that I hope to complete and submit for publication by the end of May this year. I distributed a 92-page extended summary of the report in digital format in November last year. It includes 14 tables, 16 illustrations and 50 references. I also distributed digital copies of my detailed study ***Risk and Society – an African Perspective*** (July 1999) that was commissioned by the United Nations and financed by the South African Department of Foreign Affairs. I attached two extracts to this document. They were from the UNESCO/ICSU ***Budapest Declaration on Science and the Use of Scientific Knowledge*** (July 1999), and the ***Fancourt Declaration on Globalisation and People-Centred Government*** issued by the Commonwealth Heads of Government on 14 November 1999.

My knowledge and experience relevant to this subject is as follows. I spent my childhood days in Durban where I slept under a mosquito net at night. As I now know the death toll from this disease was about 22 000 per year. I matriculated in 1941 with a second-class matriculation certificate. There was a war on and I was more interested in the troops marching through the streets, naval vessels and troop ships loading supplies and damaged naval vessels returning for repairs.

I started university studies in 1942 but when my father was taken prisoner of war at Tobruk, my mother and the university principal both agreed that I could join the South African Engineer Corps a month before my 18th birthday. I signed the oath of allegiance to my country. Spreading alarm and despondency was a punishable offence. I spent the rest of the war in North Africa and Italy. I slept under a mosquito net again in Tripoli at the edge of the Sahara Dessert at the end of the North African campaign. Eventually this disease caught up with me in Florence where I was hospitalised. Otherwise I emerged from the war unscathed in body but richer in an appreciation of the values of life.

I completed my university studies in 1949 with a BSc degree in civil engineering without difficulty or distinction. I married and joined the Department of Water Affairs (then Department of Irrigation). I spent most of the next 20 years in the field building dams, canals, pipelines and tunnels, including the 82 km long Orange-Fish Tunnel which was the longest in the world. These activities were in the sun-dominated climate of the arid Karoo and Cape Midland regions of South Africa.

In 1970 I was appointed Chief of the Division of Hydrology. My responsibilities included the collection and publication of the large volume of hydrological data necessary for water resource development and management in a water-scarce country. I was also responsible for conducting research in water resource development and the design of structures exposed to flood damage. A major challenge was the search for multi-year river flow prediction capabilities.

I was later promoted to Manager of Scientific Services where I was responsible for the activities of the three hydrological divisions including the Hydrological Research Institute. I served on a number of national and international scientific bodies.

In 1985 after a long and very satisfying career in the government service, I accepted an appointment as professor in the Department of Civil and Biosystems Engineering of the University of Pretoria. In addition to my teaching responsibilities, I continued my research on water resources and floods.

From the early 1990s I became increasingly involved in studies of the potential consequences of climate change in my fields of interest. My first paper on this subject was ***Floods, droughts and climate change*** (1995) published in the South African Journal of Science in August 1995. I successfully predicted that the current drought conditions would be broken by widespread, severe floods. This prediction was based solely on the statistically significant, regular, and therefore predicable multi-year properties of river flow. The IPCC documentation continues to deny its existence.

Also in the early 1990s I volunteered to assist with the development of measures to reduce the risks of loss of life and possessions of the tens of thousands of people who had migrated to urban areas where they established informal settlements in areas vulnerable to flooding. Through a chain of circumstances this led to my appointment to the United Nations Scientific and Technical Committee on Natural Disasters and chairman of its subcommittee on Early Warning Systems. In 1999 I was commissioned by the United Nations to carry out a study that I titled ***Risk and Society – an African Perspective*** (1999)**.** The possible effects of climate change on natural disasters were never seriously raised during the International Decade that ended in 2000.

It was from about 2000 onwards that the climate change issue gathered momentum. The concerned scientists were from the natural sciences, principally climatology and the environmental sciences. Their scientific approach and analytical philosophy was fundamentally different from that used in the engineering and the applied sciences.

I had a sound knowledge of the anomalous properties of multi-year sequences of rainfall and river flow. Based on my studies and the wealth of data on this subject, I considered that it was highly unlikely that it would ever be possible to derive these essential properties for practical applications, from a theoretical study of the atmospheric and oceanic processes. The only route that would lead to establishing this linkage would be to work in reverse by applying well established observation theory to a large data set consisting of a number of hydrometeorological processes in different climatic regions, and search for multi-year characteristics that occurred concurrently. Only then would it be possible to apply process theory to describe them.

As is well known, climate change scientists refused to acknowledge the validity of this approach and denigrated those who disagreed with them. This discouraged scientists who were not prepared to be labelled as practising pseudo-science. Claims of consensus views are false, as the vast majority of those in the engineering and applied sciences either disagree or are indifferent. I discussed this difficulty on a number of occasions in South Africa and overseas. The unanimous views were that the postulated adverse consequences of climate change are little more than untested hypotheses in the absence of statistically verifiable confirmation.

The obvious place to start is to clarify the centuries-old problem of the effect of variations in solar activity on terrestrial climate. This requires a prior knowledge of the multi-year characteristics of the processes.

4. Historical perspective

4.1. 1876 to 1889. Hutchins

R.E. Hutchins was one of a generation of scientists and civil engineers who served in the British Colonial Office in India and then migrated to South Africa. He was stationed in Mysore, India when, in 1876, 1.5 million people out of a population of 5 million in the state starved to death during a severe drought. It had been noted previously that there were linkages between sunspot numbers and famines dating back to 1810. These were characterised by droughts being broken by severe floods associated with periods of sunspot maxima. Many scientists at that time, including Hutchins, were involved in the search for predictable linkages between droughts and sunspot numbers. Hutchins detailed their efforts in his book ***Cycles of drought and good seasons in South Africa*** (1889).

He came to South Africa in 1883 where he continued his research. He studied documents and had discussions with others who had observed that droughts in South Africa were often broken at 11-year intervals by floods that occurred in 1822, 1841, 1863, 1874 and 1885 coincident with sunspot maxima. Hutchins made a number of pertinent observations in his book that remain valid today. These include:

> *I found that there was a close correspondence between the average price of food grain and the average number of sunspots. Many sunspots: good rains and cheap grain. Few sunspots: bad rains and dear grain.*
>
> *What that correspondence is can be seen at a glance by inspecting the sunspot curve and the rainfall curve, shown together in this diagram. The yellow line rising steeply to a maximum and then falling away gradually to a minimum is the sunspot curve - a curve which ought to be graven on the mind of every man and woman in South Africa. If our merchants had had this curve in their heads they would have hesitated before shipping mealies from South America at the end of 1885, when there was such a strong probability amounting almost to a certainty, that the breaking up of the drought was impending.*

Hutchins also showed that the linkage between floods that broke the drought and sunspot numbers was greatest in the temperate climates and did not appear in the tropics nor in Europe and North America, which were further from the equator. His studies were driven by a real need and were not just an academic enquiry.

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.

4.2. 1950. Hurst's Ghost

In 1950 the civil engineer R.E. Hurst analysed 1080 years of data recorded in the Nile River in Egypt, in order to determine the required storage capacity of the proposed new Aswan High Dam. He found an unexplained anomaly in the data. Using graphical methods he then analysed other long geophysical records, where he found the same anomaly. The phenomenon became known as Hurst's Ghost. His observations were the subject of many subsequent investigations.

It is now obvious that the anomalies observed by Hutchins in the 1880s and those by Hurst 70 years later are directly related to climatic perturbations. If these are regular occurrences, then they should be predictable.

Prior to my studies, neither climatologists nor hydrologists succeeded in describing these very important climate-driven processes mathematically, notwithstanding the fact that they are undeniably present and hydrologically meaningful.

I return to this later.

4.3. 1966 to 1970. Commission of Enquiry into Water Matters

In 1966 the South African government appointed a multidisciplinary Commission of Enquiry into Water Matters. The Commission published its report in 1970. The following extract from the report is relevant to this study.

> *Forecasting of climatological conditions:*
>
> *Very great advantages in the management and practical utilisation of our water resources would follow if a measure of reliability could be achieved in the long-term forecasting of climatological conditions. If the rainfall for a year ahead could be predicted with some certainty, advance decisions could be taken, with the result that the available water resources could be more efficiently utilised.*

For some time past, attempts have been made to establish a correlation between rainfall and sunspot cycles, but in South Africa there seems to be little connection between sunspot activity, or changes in the intensity of sunspot activity, and rainfall.

Several pages of the report were devoted to research on this topic. They varied from the optimistic to the pessimistic. For example:

At the beginning of the present century, the famous astronomer, Sir Norman Lockyer, wrote that one of the foremost achievements of the new century would be to forecast well in advance the incidence of famine in India or drought in Australia by means of analyses of sun-spot spectra. Lockyer thus implied that a solution to the problem of long-range forecasting was practically in sight. He was evidently convinced that sunspots were responsible for all large-scale variations in climate…

There is, at the moment, no satisfactory model to explain the inter-relationship of the sun and the earth's atmosphere. It is also highly questionable whether sun-spot numbers, data for which are readily available and extend over many years, constitute the best parameter for describing the sun's activity.

Investigations by Abbot, Claydon and several other researchers nevertheless furnish adequate evidence of an orderly relationship between the sun's activity and the frequency of certain types of weather conditions and this clearly deserves further examination. There are frequent occurrences of other meteorological phenomena that cannot be explained on the presumption that the earth and its atmosphere constitute a closed system, so it follows that investigations are called for into possible influences beyond the earth's atmosphere.

Compare this balanced view presented by the South African Commission of Enquiry more than 30 years ago with the entirely dismissive statement in the IPCC's ***Summary for Policymakers*** published thirty years later in 2001**.**

Natural factors have made small contributions to radiative forcing over the past century:

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.

4.4. 1978 to 2006. Alexander

In my technical report ***Long range prediction of river flow: a preliminary assessment*** (1978a) published by the Department of Water Affairs, I demonstrated that sudden periodic changes occur in most South African rivers. I continued:

The purpose of the present assessment is to examine the records of river flow in South Africa in an attempt to ascertain whether they show a periodicity or correlation with sunspot phenomena that could be used as a predictive tool.

I concluded:

While there is some visual evidence of correlation between river flow and sunspot numbers, both phase and amplitude differences are too large for this relationship to be used for predictive purposes. The phase and amplitude of the sunspot cycles themselves are not accurately predictable which compounds the difficulty.

However, I continued my studies and observed the behaviour of annual flows in the Vaal River. Over the following years it was fascinating to see the cumulative departure curve follow the pattern of previous sequences. The periodicity had not yet reached the 95% level but the signal was very clear. I developed a simulation model that I presented at several South African and overseas conferences. By 1993 I was very confident that the next reversal would occur within two years. I submitted my paper ***Floods, droughts and climate change*** (1995) to the SA Journal of Science in 1993. It was published in August 1995. Severe floods occurred over southern Africa from November 1995 onwards. The country-wide drought was broken and the periodicity reached the 95% level of statistical significance in the Vaal and many other rivers.

I continued with my research along these lines as and when circumstances permitted. During the past year I solved the problem identified by the Commission of Enquiry into Water Matters more than 35 years ago, and fulfilled Lockyer's century-old prediction. I have produced a multi-year climate prediction model that can be applied for the development and planning of scarce water resources. It is a world first. In the process, I have demonstrated very serious deficiencies in current climate change science. Details are available in my publications listed in the references.

The rest of this report on climate change science is in three parts, the scientific basis, the natural environment, and the socio-economic concerns.

PART 1: THE SCIENTIFIC BASIS

5. Definition of climate change

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 claimed that natural factors have made small contributions to radiative forcing over the past century. Reference was 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).

5.1. Recent climatic reversal

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 average 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 that I also successfully predicted. 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 report 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.

5.2. 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.

5.3. The hockey stick

Graphs showing the Earth's surface temperature for the past thousand years are the centrepiece of the IPCC's ***Summary for Policymakers.*** They show a gradual decrease from 1000 AD to 1900 AD followed by an exponential increase from about 1900 onwards. This has been named the hockey stick because of its shape. The data for the period prior to historical records was derived from proxy data based on tree rings, corals and ice cores.

This proxy data was used by climate change researchers to develop the critically important models for climate change scenarios. 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 1940 to 1970.

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.

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 in their 1968 paper ***Noah, Joseph, and Operational Hydrology*** 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.

A year later in their paper ***Some Long-Run Properties of Geophysical Records*** (1969) they examined a range of proxy records to determine whether the Hurst phenomenon was present. They tabulated the results obtained from 12 varve deposits (freshwater lake sediments) from Canada, Sweden, Argentina, the Himalaya mountains and East Africa; tree ring indices from 27 sites in Canada, USA, Mexico and Argentina; annual precipitation from nine sites in the USA; annual river flow from six rivers in Sweden, USSR, Switzerland, Romania, USA, France and the Nile River. They also examined sunspots, earthquake frequencies, and river meanders.

They found that the Hurst phenomenon was present in all the records and concluded:

> *We have shown elsewhere that the behaviour of the R/S means that the strength of long-range statistical dependence in geophysical records is considerable…Thus, for practical purposes geophysical records must be considered to have 'infinite' span of statistical interdependence.*

Other stochastic hydrologists and statisticians also sought clarity on the long-term properties of hydrologically important data. 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.** [My emphasis.]

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 multi-year anomalies in the data. They have developed complex models of global climate based on proxy data that exhibits the same anomalous behaviour. What this all means is that there remain as yet unexplained anomalies in both the historical as well as the proxy data that are not accommodated in the development of their global climate models.

5.4. Droughts

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. 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 1978a). 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.

5.5. 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.

5.6. 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 other than melting ice sheets and glaciers, there were undeniable, progressive, adverse changes during historical times that could reasonably be associated with exponentially increasing global temperatures. The fact that the IPCC is not in a position to produce a final report also demonstrates that many doubts remain to be resolved. It is nowhere near meeting the requirement of beyond reasonable doubt.

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**.

6. 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.

However, 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.

6.1. 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 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.

6.2. 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 numbers 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.

6.3. 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).

6.4. 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.

6.5. 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.

6.6. 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 (1978a) and successfully used to predict the climate reversal from drought to flood sequences that occurred in 1995. (Alexander 1995).

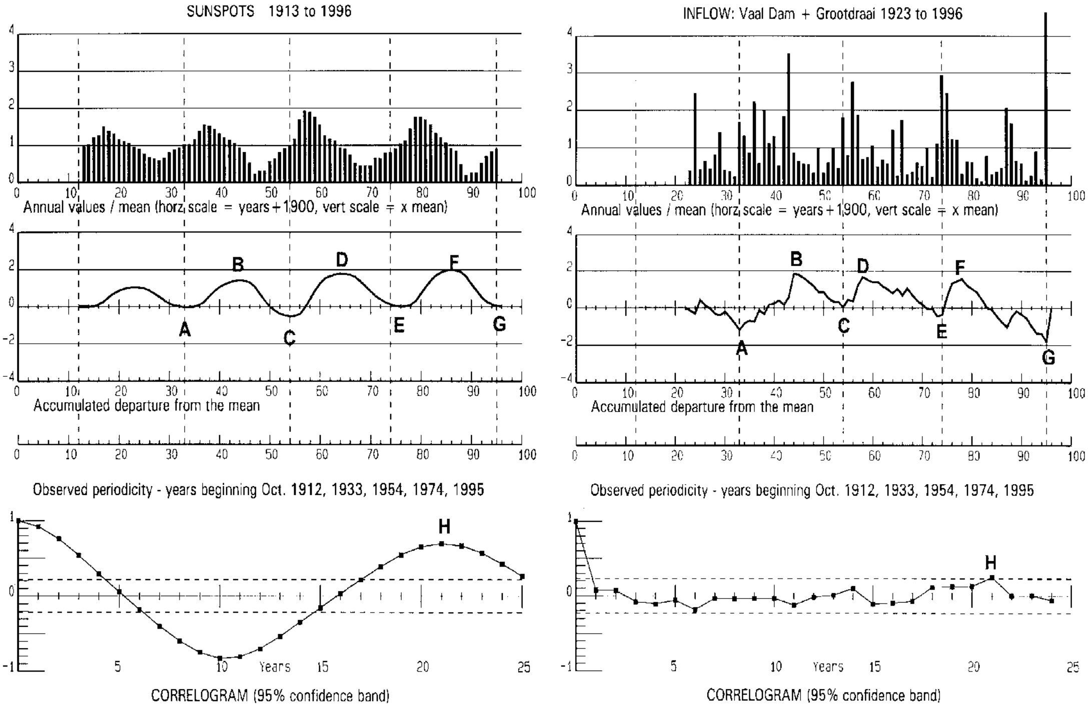

Figure 1. Comparison of the characteristics of annual sunspot densities with corresponding characteristics of the annual flows in the Vaal River.

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 occurred 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.

6.7. 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.)

6.8. 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.

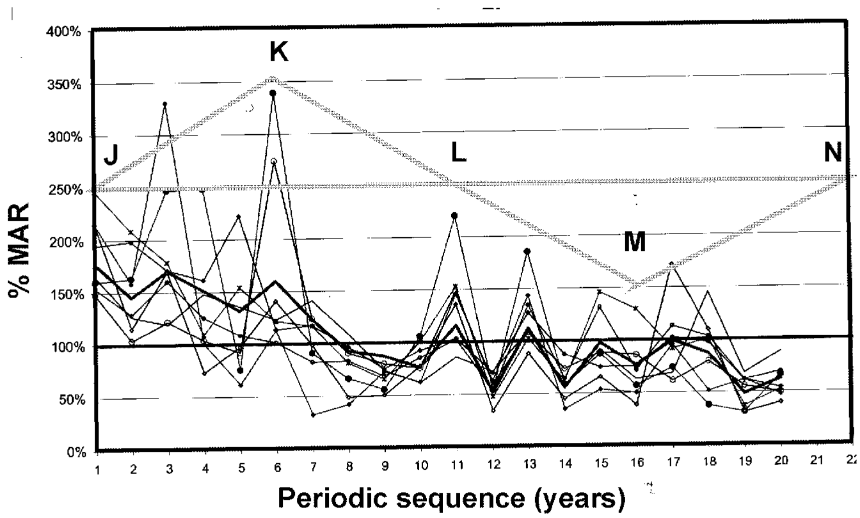

Figure 2. Characteristics of the periodic sequences of river flow at representative dam sites. The double sunspot cycle is diagrammatically superimposed.

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.

6.9. 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.

6.10. 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, 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 6 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 6. 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.

6.11. 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 report. 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 that I developed is described in Alexander. (1994, 1997, 2005a).

6.12. 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 2005. The sunspot minimum that identifies the end of the 23^{rd} 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 period of time (weeks, months or years 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.

Within the last month (March 2006) there have been reports of unusually severe tropical cyclones in Australia, tornados in the USA, and floods in Europe. I believe that these events confirm my conclusions of a global linkage with the present period of sunspot minima.

7. 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. Predictions based on GCMs that South African climate will become drier in future are clearly in error. The GCM outputs and the theory on which they are based are fundamentally inaccurate and unreliable.

There is no evidence of changes in climate in South Africa 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 scientists are groundless.

8. 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 and can be replicated without difficulty. No mathematical models were used in the analyses.

PART 2: THE NATURAL ENVIRONMENT

9. Climate change and the natural environment

9.1. Purpose

The purpose of this part of my report is to inform readers that, based on my detailed studies during the past four years, my long experience, and the wealth of data available in South Africa, there is no evidence to support the theory that climate change resulting from human activities will have a measurable, undesirable effect on the natural environment or agricultural practices.

I have a great love of the environment and I share everybody's concern regarding the steady degradation. I am particularly concerned and dismayed by the unfounded, alarmist claims by a small section of the scientific community. It is NOT the purpose of this report to criticise the researchers but to highlight what I believe are serious shortcomings in their assumptions and conclusions relating to the interactions between climatological processes and the natural environment responses. **All of this is within the context that these research findings are being used to justify drastic measures that will inevitably have an adverse effect on the prosperity of this country.**

9.2. Press release

On 5 May 2005 the Office of the South African Minister of Environmental Affairs and Tourism (DEAT) issued a press release titled ***South Africa braces for impacts of climate change: major conference to be held in October***. Many local newspapers and magazines carried excerpts from the release in articles on climate change. The emphases are mine.

It contained a statement that:

> *The simple truth however is that the climate is everyone's concern, as over the next 50 years it may well define the worst social, economic and environmental challenges ever faced.*

It went on to say that:

> *Climate change could lead to provinces such as Mapumalanga, Limpopo, the North-West, KwaZulu Natal and even Gauteng becoming malaria zones by 2050. In less than 100 years, the research indicates that thousands of plant species may well be extinct starting with a massive reduction in the distribution of fynbos and succulent Karoo biomes. With clean water resources becoming increasingly scarce, small-scale agriculture is likely to be hard hit with less rainfall in certain regions and too much in others. In short, climate change will intensify the worst effects of poverty through losses in biodiversity, agriculture, health and almost every sector of society. The government climate change response strategy kicks off with a series of events in October, including a conference of African scientists with a national conference on climate change.*

Other postulated threats were rising sea levels and expanding deserts. No solutions were offered. If this view is sound, then South Africa is on the brink of an economic disaster. I can hardly think of a more alarmist statement of national policy.

The reliability of the science on which this press release was based is the subject of this report.

9.3. What is climate?

Strangely, there is no clarity on the definition of 'climate' itself. Nor does the principal climate change literature attempt to distinguish between causes and consequences. For example, the authoritative IPCC's ***Summary for Policymakers*** (2001), makes no attempt to define climate. The heading of the very first section of the summary is '*An increasing body of observations gives a collective picture of a warming world and other changes in the climate system'.* This introductory section includes information on increasing average surface temperatures; decreasing snow cover; rising sea levels; increasing rainfall; increasing heavy rainfall events; increasing cloud cover; changes in El Niño; and changes in the frequency and intensity of floods and droughts.

Similarly, the authoritative book by Houghton (2004), who was closely involved with the IPCC, ***Global warming. The complete briefing*** (p2) defines climate as '*The climate of a region is its average weather over a period that may be a few months, a season or a few years. Variations in climate are very familiar to us.*' This is not very helpful.

Why do climate change scientists find it so difficult to introduce their readers to the simple cause-effect relationship that should be the core of their studies, and more importantly in their public pronouncements? The sequence is as follows. Increasing industrialisation and the use of fossil fuel driven transport, result in increasing discharges of undesirable gasses (principally carbon dioxide) into the atmosphere. This creates a greenhouse effect. The suppression of outgoing radiation results in a warming of the global atmosphere. This warming is evident in the observed melting of polar ice sheets and continental glaciers. It is this warming not the greenhouse gas emissions (GGEs) themselves that is the cause of other consequences. So far so good.

All too often, climate change scientists then continue by maintaining that the observable increase in temperature is 'proof' of the undesirable consequences. This is not so. These linkages have to be established. I have found no observational support for these linkages in South Africa.

Notwithstanding all the evidence to the contrary and the wealth of data, predictions have been made by a small group of South African scientists of very serious consequences of global warming arising from human activities. These predictions were not based on the wealth of South African data but on theories developed by scientists in the northern hemisphere, cold climates. The IPCC was established in 1988 and issued assessment reports in 1990, 1995 and 2001. More money and more scientific effort have been spent on climate change research than in any other scientific field. Yet today, 18 years after the establishment of the IPCC, the only meaningful effects of global warming have been the melting of polar ice sheets (contested); the retreat of glaciers (some have advanced); and the melting of the snows on Mt Kilimanjaro. As I will show in this report, there have been no meaningful adverse changes in any environmental processes or agricultural responses that can be attributed to unnatural climate change.

The analyses lead to the conclusion that current global climate models (GCMs) are inherently incapable of replicating past climate or predicting future changes at time and space scales required for practical applications.

9.4. The evidence

9.4.1. Global warming has increased temperature

In their paper ***Temperature trends in South Africa: 1960-2003*** (2004) Kruger and Shongwe reported that 23 of the 26 climate stations analysed showed positive temperature trends. Two warm phases were identified: the first was from the mid-1930s to the late 1940s, and the second was from the early 1980s to the end of the period of study. The trends in the annual mean temperature were at the lower end of the range 0.1 to 0.3 ^{0}C per decade. This is equivalent to an increase of 1 ^{0}C to 3 ^{0}C per century.

They also found that the trends had not themselves increased during the past decade. This is notwithstanding the IPCC (2001) statement that the 1990s was the warmest decade and 1998 the warmest year in the instrumental record. Nevertheless, the increase in South African temperatures correlates well with the global trend.

By definition, temperature is the most emphasised consequence of global warming but there are some problems. Firstly, temperature is a measure, not a process. It has to be coupled with something, for example, air temperature at various levels of the atmosphere, sea surface temperature, land surface temperature, the vertical temperature profile of water in a dam, and so on. Secondly, it is a measure of heat energy. Heat energy in turn is one of several forms of energy. The energy cycle shows how energy is transformed from one form to another during the various atmospheric, oceanic and terrestrial processes.

If glaciers and ice caps are melting this is confirmation of a global increase of air temperature. But this is meaningless in itself. The linkage between increase in air temperature and all the other undesirable consequences still has to be demonstrated by observation and not simply postulated by contestable theory.

9.4.2. Global warming has increased evaporation

Solar radiation is converted to heat energy when it strikes a heat-absorbent surface such as water, soil and vegetation. If water is present, its temperature will increase and some of the additional heat energy will be converted to latent heat of evaporation, as water is lost to the immediate atmosphere.

Incoming solar radiation drives the system. Its effects can be reduced by cloud cover, but never increased. Evaporative loss is also dependent on the movement of warm, dry air across the water surface. This also has an upper limit. Taken together, there is a maximum, upper limit to evaporation losses from open water, soil and vegetation. This maximum is approached in hot, dry, cloudless conditions.

My studies of 1176 years of data from 20 representative observation stations showed that there was an increase at 14 stations, no change at two stations, and a decrease at four stations.

In a paper discussed later in this report, it is stated that GCM outputs predict a quadrupling of the evaporation over a large, semiarid region of the African subcontinent. Quadrupling of evaporation losses in a semiarid region is physically impossible and casts serious doubts on the reliability of the GCMs and the knowledge of those who accepted the results.

9.4.3. Global warming has increased rainfall

> *Rainfall over the southern parts of the region* (southern Africa)*, as a whole has shown no large systematic linear trends during the twentieth century.* (Tyson and Gatebe 2001.)

I was 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. This contradicts the statement by Tyson and Gatebe that there has been no change. This denial of the beneficial consequences of global warming has become a trademark of climate change scientists.

In 1993 the University of Pretoria hosted a discussion group organised by the Department of Water Affairs and Forestry (DWAF) on the possible effect of climate change on water resources. Differences of opinion were expressed, but one of the conclusions was that climate change was likely to increase rainfall, not decrease it. This conclusion was eight years before the IPCC (2001) policy statement.

The results of my recent investigations show that there has been a sustained increase in the mean annual rainfall over South Africa from 497 mm to 543 mm during the 78-year period of continuous district rainfall records. This agrees very well with the IPCC figure of a worldwide increase of between 0,5 to 1% per decade during the 20th century. My observation is reinforced by the concurrent increase in open water surface evaporation that increases atmospheric water content, which leads to the conclusion that any additional global warming will further increase the annual rainfall over South Africa, not decrease it. This is in accordance with current international observations and opinions. This fact negates climate change scenarios that postulate either no change, or a decrease in rainfall.

Over almost the whole of South Africa the annual rainfall consists of a mixture of discrete high and low rainfall events. But it is the high rainfall events that saturate the soils, sustain natural vegetation, provide moisture for agricultural crops and generate river flow. The low rainfall events make a minimal contribution to these processes. An increase in rainfall variability will result in an increase in rainfall from high rainfall events and will therefore be beneficial.

The claims that the seasonal and daily properties of rainfall may have been adversely affected by climate change despite the general increase in rainfall are illogical. This is firstly because the increase is the consequence of the increase in the frequency of beneficial, widespread, heavy rainfall events, and secondly because the ability to detect change decreases rapidly with decrease in time and space scales.

Then there is the matter of elementary physics and logical deduction. Surely, everybody knows that an increase in global temperature must result in an increase in evaporation from the oceans, lakes, dams, rivers, vegetation and the soil. It is equally obvious that all this excess moisture must return to earth in the form of increased rainfall. There is no theoretical or observational justification for the assumption that global warming will decrease South African rainfall.

I return to this subject in a later section of this report.

9.5. The consequences

9.5.1. Global warming will not spread malaria

> *Climate change could lead to provinces such as Mapumalanga, Limpopo, the North-West, KwaZulu Natal and even Gauteng becoming malaria zones by 2050.* (DEAT press release 5 May 2005.)

It has been claimed that global warming will result in the spread of malaria to areas where it is not present in South Africa. When I was a child living outside Durban I slept under a mosquito net. I slept under a mosquito net again during the war at Tripoli on the edge of the Sahara desert. A year later I contracted malaria south of Florence in Italy. A few months later I slept under mosquito nets again on the Adriatic coast of Italy, which experienced winter snows. There could hardly be a greater climatic contrast between the heat of the Sahara Desert and the snows of Italy.

Climate change scientists must surely be aware of the thorough study by Paul Reiter ***Climate change and mosquito-borne disease*** published in 2001. The twenty-page report has 189 references. He provides interesting historical information on the prevalence in northern hemisphere cold climates as well as the DDT fiasco. Malaria occurred throughout Europe during the Ice Age of the 16^{th} and 17^{th} centuries. I contracted it in Italy in 1944. Since then it has been eradicated from Europe.

Reiter's concluding comment was:

> *The natural history of mosquito-borne diseases is complex, and the interplay of climate, ecology, vector biology, and many other factors defies simplistic analysis. The recent resurgence of many of these diseases is a major cause for concern, but it is facile to attribute this resurgence to climate change. The principal determinants are politics, economics, and human activities. A creative and organised application of resources is urgently required to control these diseases regardless of future climate change.*

I have also received a lot of information from professional colleagues. Returning closer to home, only 16 deaths were reported in South Africa in 1974 after which DDT was banned. Twenty years later the death toll rose to thirteen thousand as a result of the banning. Another personally interesting statistic is that in KwaZulu-Natal in 1932 when I spent my nights under a mosquito net, the annual death toll was between 10 000 and 22 000. Malaria was later eradicated by DDT.

I have been informed that most countries in southern Africa either already have DDT spraying programmes or are about to introduce them. Where DDT has been introduced there has been a dramatic decrease in the incidence of malaria. There is also no evidence that DDT is harmful to human beings. The Department of Health has produced figures showing the numbers of cases and deaths per annum for the Northern Province, Mpumalanga, KwaZulu-Natal and the rest of South Africa for the years 1999 to 2004. For South Africa as a whole, the total deaths were 406, 458, 119, 96, 142, 89, and 36.

In a recent press release (DEAT 5 May 2005) the public were informed that global warming could lead to provinces such as Mpumalanga, Limpopo, the North West KwaZulu-Natal and even Gauteng becoming malaria zones by 2050. What then is the basis for this claim that climate change could result in a reintroduction into areas in South Africa where it was once prevalent but has since been eradicated by chemical and other control measures?

The question then arises. Did those who made this alarmist statement make any effort to study the wealth of literature on this subject, or even more importantly, discuss the issue with South African experts in this field? If not, then why not?

9.5.2. Global warming will not result in desertification

> *The drier parts could even resemble the Sahara, and South Africa could end up looking like Mauretania, Mali and Chad, where desertification is so serious, the camel is the most reliable form of transport.* (Introduction to Futures of the Karoo conference 1978.)

In 1925 the Department of Agriculture published a detailed report ***The great drought problem of South Africa.*** The report was presented by a five-person commission of enquiry appointed by the government in 1920.

The following quote from the study is repeated here.

> *…the Commission states that two points seem firmly established: firstly that a large portion of South Africa was dry long before* (settlers from Europe) *arrived, as evidenced by the name "Karroo" and by the highly specialised drought-resisting flora of that region; and secondly, that since then enormous tracts of the country have been entirely or partly denuded of their original vegetation…*(as a result of poor farming practices.)
>
> *The simple unadorned truth is sufficiently terrifying without the assistance of rhetoric. The logical outcome of all is 'The Great South African Desert' uninhabitable by man.*

This is the first reference to the desertification of the sub-continent – a recurring theme that continues to the present day. Note in passing the reference to the highly specialised drought-resisting flora of the Karoo region.

In 1953 J Acocks produced his Veld Types map of South Africa and the phrase of the 'marching desert' became popular. The government introduced several measures such as stock reduction schemes, while farmers introduced rotational grazing procedures. The situation is now under control.

In the 1970s, despite all the scientific evidence to the contrary, the World Meteorological Organisation predicted that the rainfall over large areas of South Africa would decrease **as a result of global cooling**, and desert conditions would prevail.

A conference on ***The future of the Karoo*** was held in Graaff-Reinet in November 1978. I was one of seven invited speakers. The title of my presentation was ***Man, water and the soil***, (Alexander 1978b). The reason for the conference was the alarm caused by the report by the World Meteorological Organisation.

> *According to the World Meteorological Organisation, our beautiful land is turning into a desert. They say the Karoo is expanding at such an alarming rate that by 2050, it could reach Mafeking and Vereeniging in the north, East London in the east and Barkly West in the west.*
>
> *The drier parts could even resemble the Sahara, and South Africa could end up like Mauretania, Mali and Chad, where desertification is so serious, the camel is the most reliable form of transport, and the remaining arable lands cannot support the population, so hundreds of thousands die of starvation and disease.*

I informed the conference that the fears were groundless. The only camels in South Africa are in the zoos.

Remobilisation of the Kalahari sands

The following is an example where the lack of elementary knowledge and unjustified reliance on global climate models led to a completely false alarmist view. The claim was that there would be a progressive desertification of a huge area of southern Africa, including the whole of Botswana and large areas of South Africa, Namibia, Zimbabwe, Angola and Zambia, during the present century as a result of uncontained climate change. This claim was made by Thomas, Knight and Wiggs in their article in Nature ***Remobilization of southern African desert dune systems by twenty-first century global warming*** (2005)**.** It is very impressive on the surface with 17 figures and 29 references.

The Kalahari sands are the most extensive body of sand in the world. They stretch from Upington in the south, beyond the Caprivi and into Angola and Zaire in the north. They include eastern Namibia, virtually the whole of Botswana and western Zimbabwe. The climate ranges from near desert conditions in the south, grasslands in the middle and dense woodlands in the high rainfall regions in the north.

My favourite travelling companion for many years was Lester King's ***South African scenery. Textbook of geomorphology*** (1963), and more recently ABA Brink's ***Engineering geology of southern Africa*** (1985). Both of them deal with the Kalahari dunefields in some detail. I have travelled extensively through this area and have many photographs showing the vegetal cover. I have also conducted an extensive study of the geomorphology and vegetal cover of the Caprivi by helicopter and by boat. This is within the region covered by the authors.

This is a quote from Brink (p175).

> *Of great interest because of their extremely widespread occurrence are the superficial cover sands and fossil dunes, which attest to the presence of an enormous sand sea at a late stage of the history of the Kalahari basin. Today these sands are mobile only where there are regular sources of fresh sediment, such as in proximity to the channels of major exotic rivers where disturbance has taken place. Elsewhere they are stabilised by vegetation, which in north-eastern Botswana, Angola, western Zambia and Zaire is often thick bush or even tropical forest.*

According to Juta's Magister Atlas for secondary schools (p78) the annual rainfall over north-eastern Namibia is between 500 mm and 1000 mm and increases northwards into Angola. The authors' Fig. 1 shows the rainfall to be in the range 400 to 800 mm. This can by no means be considered to be a desert! In other words, rainfall is not the limiting factor for vegetation. It is the porous soil that is unable to retain moisture. From this it follows that a reduction in rainfall will not result in a corresponding reduction in vegetation.

My major problem with the reasoning of the writers of this article, and others, is the over-simplistic views that they express. Rainfall will decrease, therefore the vegetation will die, therefore the sand will be exposed, and therefore the winds will blow the sand over wide areas of southern Africa. It is all the unaddressed 'therefores' that are the problem.

Here are a few statements made in the paper.

Empirical data and model simulations established that the interplay between dune surface erodibility (determined by vegetation cover and moisture availability) and atmospheric erosivity (determined by wind energy) is critical for dunefield dynamics.

This relationship between erodibility and erosivity is susceptible to climate change impacts. They used simulations with three global climate models and a range of emission scenarios to assess the potential future activity of three Kalahari dunefields. They found that regardless of the emission scenario used, significantly enhanced dune activity is simulated in the southern dunefield by 2039, and in the eastern and northern dunefields by 2069. By 2099 all dunefields are highly dynamic, from northern South Africa to Angola and Zambia with very serious consequences to the peoples of this vast region.

All these conclusions rested on the basic assumption that the existing vegetation would be destroyed by climate change. Without the removal of the vegetation the sand in the fossil dunes cannot be eroded and transported by wind activity. The destruction of the protective vegetation is the central issue, but was completely ignored in the paper.

In northern and eastern areas dunes are heavily vegetated, including mixed deciduous woodland in places, owing to higher precipitation levels. How can climate change possibly reduce this to a desert? Precisely what changes in rainfall and evaporation did the authors postulate will lead to wiping out all the natural vegetation over this huge area of southern Africa and lead to the claimed 'catastrophic' results?

In is only in a single paragraph that rainfall and evaporation changes are mentioned for the first and only time in the paper although these are the key factors in the whole process. This is what it said. Note the very large differences in the outputs from the different GCMs.

The first GCM predicted the **doubling of potential evaporation** over southern Africa, [this is physically impossible] by 2100 but no mention is made of rainfall.

An older model predicted a **50% decline** in summer rainfall in the northern areas accompanied by a **quadrupling of potential evaporation**. [Impossible.]

A newer model predicts a **50% increase** in rainfall and a **smaller increase in potential evaporation** but the potential evaporation still exceeds the rainfall.

Now at last the penny dropped. Because their assumption is so fundamentally absurd and incomprehensible I missed it all along. The writers maintained that because all models predicted an increase in potential evapotranspiration that exceeded any change in rainfall in all scenarios, this would result in the destruction of all the protective vegetation even if the rainfall increases by 50%, i.e. to more than 1000 mm per annum in the northern areas. They clearly did not understand the meaning of the word 'potential'.

If reference is made to the annual evaporation map of South Africa where evaporation is expressed as a multiple of the annual rainfall, it will be seen that open water surface (i.e. potential) evaporation exceeds rainfall over virtually the whole of South Africa. The authors were apparently blissfully unaware of this fact, and assumed that if potential evaporation exceeds the rainfall, no vegetation can survive. This is the foundation on which their paper is based.

I do not for one moment believe that an area that presently receives an annual rainfall between 500 and 1000 mm; and is well vegetated; will lose all its vegetal cover; exposing the underlying readily erodable sand; which will cause the dunes to be reactivated and invade large areas of southern Africa – all because the GCMs predict an increase in potential evapotranspiration.

An alternative explanation is that the relationship between erodibility and erosivity is susceptible to climate change impacts, and that these changes will result in the remobilisation of the fossil dunefields. This cannot be so, as the dense vegetal cover will prevent any wind erosion on the required scale.

There is no believable foundation for the claim that:

> *...changes in the erodibility and erosivity of the dune system* (arising from climate change) *suggests that the environmental and social consequences of these changes will be drastic.*

I have travelled widely through this area. No reasonable observer would agree that these extensive, well covered, Kalahari sands could by any means be converted into a treeless, sandy desert within a matter of decades.

I have dealt with this paper in some detail as it is an example of unfounded conclusions based on a lack of knowledge of the critical processes. In the light of the seriousness of the claims, one would have expected a much more robust and watertight presentation. Claims such as these are then quoted as being reliable because they have passed through the peer-review process. They are subsequently used by organisations such as GreenPeace and the WWF to further their own agendas.

9.5.3. Global warming will not result in a loss of habitat and species

> *In less than 100 years, the research indicates that thousands of plant species may well be extinct starting with a massive reduction in the distribution of fynbos and succulent Karoo biomes.* (DEAT 5 May 2005.)

As the issue relates to global warming, it is natural to consider temperature as the dominant variable of interest. This in itself is a problem because temperature is a measure, not a process. Nor does it have upper or lower limits. Temperature has to be associated with something. In this report it is assumed that temperature refers to air temperature close to ground level unless defined otherwise. It should also be noted that:

1. The changes in temperature postulated in the IPCC documentation are very small when considered against the high, natural, hour-to-hour, day-to-day, year-to-year and multiyear variability.
2. It is rainfall, not temperature that determines the habitability of our planet, including animal and plant species. Those species that thrive in hot, dry regions have adapted to the harsh and highly variable conditions.
3. The heat energy is derived directly from solar radiation, so changes in solar radiation are of interest.
4. The role of increase in CO_2 concentrations in the atmosphere is also of interest as CO_2 is generally beneficial to plant growth.

Therefore, it is essential that concurrent changes in all four driving processes and the responses of the natural species to these complex and interacting driving variables have to be assessed where the consequences are of national importance. This is by no means a simple exercise or experiment, because the complex interrelationship between the driving variables and the responses is itself highly variable.

The second aspect that does not seem to be sufficiently accommodated in these studies is the highly variable nature of temperature on all time scales from minutes through to decades. Indigenous species have adapted to this variability, so temperature changes of the order postulated in climate change theories are very small in relation to the daily ranges of temperature in vulnerable regions.

The third aspect is the stated or implied 'delicate balance of nature' when the very opposite is true. Nature is inherently robust, not delicate, and is never in a state of equilibrium. The harsher the climate, the more robust the species that inhabit it. This was amply demonstrated in the photographs taken in the Namib Desert after the widespread sub-continental rains earlier this year. These showed sand dunes and ridges that were almost completely covered by lush grasses and other vegetation.

The fourth aspect relates to shortcomings in analytical methodology. This is dealt with earlier in this report.

It needs no more than a glance at the daily weather forecast on TV to note that the predicted (IPCC 2001) increase in global temperature of between 1.4 and 5.8 ^{0}C during the next 100 years is only a fraction of the difference between the daily maximum and minimum temperatures at any specific place in South Africa. The postulated temperature increase is also of the same order as the difference in climate between Johannesburg and Pretoria North. It is very difficult to accept that this small increase in the **average** annual temperature could result in the wholesale destruction of habitat and species.

The following are comments on two papers by National Botanical Institute (NBI) scientists and co-authors, which conclude that global warming could endanger the survival of the Cape fynbos and succulent Karoo species. These two consequences of global warming have been used to justify the view that global warming could cause irreparable damage to these biomes and habitats, and that large public expenditures to counter global warming are thereby justified. This money could be better spent on combating the real problems of poverty, malnutrition and disease. These issues must therefore be considered very seriously.

9.5.4. Threat to fynbos biomes

There are several disturbing features in the Hannah et al (2005) paper ***The view from the Cape: extinction risk, protected areas, and climate change*** in which the threats to the fynbos species are described. The first is that the phrase 'climate change' is repeated many times and is the main theme of the paper, but nowhere is 'climate' defined. The only climatic property referred to is air temperature but nowhere are the changes in temperature quantified. There is no reference at all to sustained increase in rainfall, although its role must surely be at least equal to, if not greater than changes in air temperature.

The second is that the projected changes are derived from down-scaled GCM outputs. The GCMs are not even capable of producing reliable results of the rainfall for the south-western Cape as a whole let alone for small areas. It has been predicted that rainfall in the south-western Cape will decease whereas there were substantial increases in the past and these increases will continue as long as global temperatures keep increasing.

This omission must raise doubts in the minds of an impartial observer.

The title of the paper and references to climate change should have referred to temperature changes, not climate changes. The two are not synonymous.

9.5.5. Threat to Karoo biomes

Similarly, Musil et al (2005) in their paper ***Lethal effects of experimental warming approximating a future climate scenario on southern African quartz-field succulents: a pilot study***, describe a limited experiment where the air temperature in the immediate vicinity of the plants was forced to rise by enclosing them in miniature hothouses. There is no reference to the effect of rainfall other than a single sentence:

> *Change predicted future warming* <u>*and aridity trends*</u> *sufficient to cause large reductions in species richness in Mediterranean climate Fynbos and Succulent Karoo biomes…*(My emphasis.)

But rainfall has increased over most of the area and will continue to increase in future, so the reference to aridity trends is unsubstantiated. This obviously casts doubts on the conclusions.

Nor is there any mention of wind action. The movement of air in the immediate vicinity of the plants is essential for the transpiration and consequently the movement of fluid through the plants. The enclosure of the plants must inevitably have an adverse effect by suppressing this essential process. This was not mentioned in the paper.

The next unreported issue is what proportion of the ambient temperature is directly related to solar energy input? Visualise an experiment where two spanners (say) are placed next to one another. One in the shade of a shrub and the other in the sun next to it. If the temperatures of the two spanners and the air temperature in the shade within the shrub were measured they would be different from one another, but by how much?

Another personal experience is that all our houses on construction projects had corrugated iron roofs. The sheets would expand when the sun shone and contract when a cloud passed in front of the sun. It was quite noisy, and we used to say that the roofs were 'talking' to us. Clearly the heat from solar radiation was considerably more than the ambient air temperature. All proof that was needed was to move in and out of the shade on a sunny day. Also, the temperature of the air in the vicinity of the vegetation is more the result of solar heating of the ground in the immediate vicinity of the individual plants rather than the inflow of warm air from elsewhere.

The other question is what is the postulated increase in temperature arising from global warming, when most of the heat energy in arid regions is directly from solar radiation and not from the ambient air temperature?

The authors stress that this was a pilot project but this is not how it was interpreted in the press releases. This is very important as the public, in my opinion, are being seriously misled.

9.5.6. Changes in rainfall in the southern and western Cape

How important is the omission of references to increases in rainfall resulting from global warming in the above studies?

During January 2005 the SAWS kindly sent me the recently revised District Rainfall data for the period 1940 to 2004. Other than Districts 14 (no data for the 1950s) and 58 (Lesotho) the analyses are complete. I have used this database for practical applications for the past fifteen years without any problems.

By definition climate is an areal phenomenon not a point phenomenon. The District Rainfall database is therefore an ideal database for detecting the effects of climate change, even and especially where there is a wide range of point values within the district due to steep topographic changes for example.

Should there be a need to disaggregate the climate-related properties (not the rainfall itself), this could be satisfactorily achieved by multiplying by a factor in proportion to the ratios of the point/areal average annual values.

I carried out a few calculations using the supplied data. It only took about four hours. I analysed the data for districts 1 to 20 in the western and southern Cape, which include the fynbos and the succulent Karoo regions. I divided the data for each district into three equal 21-year periods. These were from 1940 to 1960, 1961 to 1981, and 1982 to 2002 (inclusive). The use of 21-year periods neutralises the effect of the statistically significant 21-year periodicity in the data, which in turn is directly related to corresponding changes in solar activity.

Two years 2003 and 2004 were omitted in the first round of analyses. I then selected the lowest of these two remaining years and compared them with the ranked data. For example, the rainfall in District 1 for 2003 was the 5th lowest during the 65 years of record.

Interpretation of the facts

The midpoints of the 21-year sequences are 1950, 1971 and 1992. The results were as follows.

- There was a 17% (57 mm) **increase** in regional rainfall during the 42-year period 1950 to 1992, and a greater increase during the whole period of record.
- Only four districts showed a decrease in rainfall during the period of record.
- The other 15 districts with complete records all showed **increases** within the range of 2% to **68%**.
- The regional rainfall showed a **consistent increase** from the first to the second to the third periods.
- In not a single district was either the 2003 or 2004 rainfall the driest on record. For the region as a whole, the average of the worst of these two years was only the 16th lowest on record.

This very simple analysis showed that except for the three districts (1, 2 and 3) along the west coast, and the single district (12) on the south coast, all other districts in the western and southern Cape, including those in which the fynbos and most of the succulent Karoo are located, have exhibited consistent increases in rainfall during the period of record.

The SAWS weather station at Cape Agulhas at the southernmost tip of the African continent, has also recorded an increase in temperature during this period. Furthermore, it is reasonable to assume that CO_2 has also increased. If all three of these principal elements that affect plant growth have increased for the past 65 years, what is the basis for the NBI authors' alarmist predictions? Furthermore, if the rainfall analysis shows that there has been a sustained increase in rainfall during the past 65 years, and that this increase will continue as long as global warming continues, what weight should be placed on the allegation that:

> *In less than 100 years, the research indicates that thousands of plant species may well be extinct starting with a massive reduction in the distribution of fynbos and succulent Karoo biomes.* (DEAT 5 May 2005.)

Finally, why did the NBI scientists not carry out the simple analyses described here using the District Rainfall data that have been available since the 1970s? The analyses would have taken less than a day to perform, and do not require any numerical expertise other than simple arithmetic.

9.5.7. Global warming will not increase eutrophication

The following extracts are from a viewpoint article by Hart, Ashton and Allanson: ***Is climate change really no concern. A call for a more holistic vision.*** (Water Wheel May/June 2004.) I was not given the opportunity to respond at the time.

> *Will Alexander's viewpoint article suggests that climate change is of no environmental concern. Flying in the face of contemporary opinion is a brave call. But we believe it is erroneous. It simplifies, even trivializes, an issue that affects humanity at large, and demands debate.*
>
> *As a prominent water resources engineer, Will Alexander cannot be unaware of thermal stratification events in standing waters, and the eutrophication threats to our national water resource base. Yet his conclusion disregards any consideration of the impacts of warming on these crucial issues.*
>
> *Temperature plays a ubiquitous role in ecology. It is a prime determinant of habitat suitability for living organisms, and serves as the singularly most important abiotic dimension of ecological niche for virtually all living organisms.*

I am familiar with the eutrophication problem in many of South Africa's dams and I was directly involved with the implementation of control measures for a number of years, including the control of aquatic weeds. I have examined more dams, lakes and rivers in southern Africa than most aquatic scientists.

As shown earlier in this report, the rate of increase in air temperature in South Africa was within the range of 0.1 to 0.3 ^{0}C per decade. **This is equivalent to the increase in the temperature from 9 am to 10 am on a sunny day!** Did these writers really expect Water Wheel readers to believe that this very small increase in average temperature of a water body will have the postulated serious consequences?

Did they expect readers to believe that there would be progressive increase in the eutrophication or other undesirable biological activity of a series of dams on a river with their different temperature regimes, for example from Grootdraai Dam to Vaal Dam to Bloemhof Dam on the Vaal River? Or from Midmar Dam to Albert Falls Dam to Nagle Dam to Inanda Dam on the Mgeni River? Pongolapoort Dam located in northern KwaZulu Natal lowveld is probably the warmest, large, freshwater body in South Africa. Are eutrophication and other undesirable biological processes greater in this dam than in any other dam in South Africa?

If these progressive deteriorations are indeed present, why were these not quoted as examples instead of referring readers to '*the veritable arsenal of information documenting these effects'* ?

The same applies to biological activities in a river system. The water temperature will change progressively from the upper to the lower reaches of a river. Are we expected to believe that the natural biological activities change from acceptable to unacceptable along the length of the river as the temperature increases?

The implication that increases in average water temperature are undesirable, is unacceptable within the context of the very wide range of temperatures experienced in South African rivers from east to west, and from north to south, and from day to day.

The growth of undesirable aquatic weeds such as water hyacinth is largely independent of temperature. I have observed this problem in the dams and lakes from Lake Malawi in the north, Kariba Dam on the Zambezi River, through to Hartbeespoort Dam in South Africa, all of which have different temperature regimes.

I was accused of trivialising an issue that affects humanity at large, so let me provide an interesting observation. The growth of floating water hyacinths in the nutrient rich Hartbeespoort Dam became a serious problem for recreational activities, although these plants had a beneficial effect of suppressing dangerous algal growth. Responding to public pressure, the Department of Water Affairs agreed to destroy the plants by aerial spraying. Academic limnologists warned that the dead plants would sink and decay, thus deoxygenate the water in the dam. They predicted that this would result in massive fish deaths. In the event, the dead plants remained floating until they were completely decayed and not a single dead fish was found.

9.5.8. Global warming will not increase soil erosion

It has been claimed that climate change will increase soil erosion, and maps have been produced showing that soil erosion is greatest in the high rainfall areas. My earlier studies showed that there has been a decrease of sediment transport in rivers as well as sediment deposition in dams due to active anti-soil erosion measures. A walk along the hiking trails of the high rainfall areas of the eastern escarpment from the Drakensberg in South Africa all the way through to the Rift Valley in Malawi will show crystal clear streams and no evidence of active soil erosion.

Soil erosion is a natural geomorphological process. It is the result of a sequence of processes, each of which has to be satisfied before the next occurs. The sequence starts with the degradation or removal of overlying protective vegetal cover. As global warming will result in an increase in rainfall this will increase vegetal cover, not diminish it, and consequently decrease the rate of natural soil erosion where no other factors are present. In those cases where the protective material has been removed, this will expose the underlying material. The exposed material must be erodable. If it is solid rock it will not erode. At the other extreme dispersive soils are highly erodable. Thereafter there must be a detaching and transporting medium, either flowing water or less frequently, wind.

The velocity of the water must be capable of detaching and transporting the unprotected and erodable material. This is a complex process. Steep slopes result in high water velocities and therefore high erosion potential. However, steep slopes have to consist of non-erodable material otherwise they would have been flattened by natural erosion long ago. Only when all four conditions have been met can soil erosion occur.

There is no linkage between soil erosion and climate change.

9.5.9. Global warming will not adversely affect agriculture

> *Maize, wheat, sugar and cotton lands will shift and change, our famous southern Cape vineyards are likely to shrink, fungal rusts, weevils and worms, along with parasite-vectoring mosquitoes are likely to change or otherwise change their distribution ranges – either in space and/or in time.* (Hart, Ashton and Allanson 2004)

There is no foundation for these alarmist claims. Were experts in agriculture, entomology and tropical diseases consulted?

9.5.10. Global warming will not result in a drop in food production

> *There will be a drop in food production including an estimated drop of 20% in grain production.* (DEAT 15 December 2004.)

The 2004/05 maize harvest was the biggest since 1994 and there was a surplus of 4 million tonnes. Maize farmers are now seriously considering using maize surpluses for the production of ethanol for use as a fuel.

Increases in temperature, rainfall and atmospheric carbon dioxide are beneficial to agriculture.

There is no foundation for this prediction.

9.5.11. Global warming will not increase health problems

> *Climate change will have a major impact on our people with health problems like increased cancer rates. Waterborne diseases will increase.* (DEAT 15 December 2004.)

The postulated changes in climate will be no more serious than moving from Johannesburg to Pretoria, or from Pietermaritzburg to Durban, or vice versa. The principal risk of incurring skin cancer is exposure to solar radiation, not an increase in temperature. The risk of contracting waterborne diseases such as cholera is associated with poor hygiene, not climate.

9.5.12. Global warming will not increase droughts

> *Changes in temperature and precipitation regimes in future, particularly in respect of extreme drought and flood conditions, will have profound effects.* (Tyson and Gatebe, 2001.)

It has been postulated that global warming will result in an increase in the frequency and magnitude of droughts. The study of the concurrent properties of the annual hydrometeorological data series was the main thrust of my recent studies. Sequences of wet and dry years in both rainfall and river flow are natural phenomena that have been observed and reported since biblical times. I found no support for the view that global warming will increase the likelihood of droughts in southern Africa. Such increases that may have been observed are the result of variations in solar activity.

9.5.13. Global warming will not increase floods

> *Any temperature or rainfall record shows a large variability. The inevitable result of variability added to higher average temperatures (meaning higher evaporation) and higher average rainfall will be a greater number and greater intensity of both droughts and floods.* (Houghton 2004.)

Droughts and floods are fundamentally different hydrological phenomena and are not processes at two ends of a continuous scale. The principal concern regarding droughts is the long sequences of years of deficient rainfall whereas for floods it is their short duration (measured in hours).

Major floods in southern Africa are highly destructive, largely due to the steep slopes of the rivers and exposure to widespread, severe flood-producing rainfall events, including tropical cyclones and equally destructive cut-off low-pressure systems.

Consequently research on floods has received more attention than in most other countries of the world. The floods recorded in the 1850s remain the highest on record in several rivers. In 1856 the Mgeni River overflowed its banks and flowed across the centre of Durban and into Durban harbour.

Climate change does not feature in research on floods as any change, should it be present, would be overwhelmed by the natural variability. (See Alexander 2002 ***Statistical analysis of extreme floods.***) Claims have been made that the world-wide increase in the loss of life and damage by floods is the result of global warming. This is not so. They are the result of increases in the vulnerability, as population growth forces disadvantaged communities to occupy flood-prone areas. This has been my personal experience and is well supported in the literature on natural disasters.

9.5.14. Global warming will not threaten water resource management

> *As a consequence mainly of anticipated changes in precipitation, the UKTR95 scenario for 2050 shows decreases in annual runoff of the order 0-40% over much of South Africa. From a perspective of water resources management however, equally significant changes to those of mean annual runoff are increases of 10-20% in the interannual CV of runoff. These increases could add to the cost and complexity of managing water resources by requiring increased storage capacities as well as more stringent reservoir operating rules in regard to releases in dry years.* (Schulze, Meigh and Horan 2001.)

> *The certainty of prolonged and intense water restrictions.* (DEAT 15 December 2004.)

The paper by Schulze, Meigh and Horan: ***Present and potential future vulnerability of eastern and southern Africa's hydrology and water resources*** (2001), is an excellent example to illustrate the unanimous views of the world's leading scientists in water resource analyses with whom I have discussed the issue, that climate change scenarios are no more than untested hypotheses that have no place in water resources development and management.

In southern Africa in general, and South Africa in particular, we have a wealth of routinely observed hydometeorological data that is collected at a rate of about half a million station-days per year. Many rainfall records exceed 100 years in length and many river flow records exceed 80 years in length. Yet this wealth of data is totally ignored by these authors who rely solely on the outputs of global climate models and simplistic rainfall and runoff model assumptions for their analyses.

In the abstract of their paper it is stated that:

> *This paper presents a synthesis of water as a vulnerable resource in space and time under present climatic conditions by assessing various rainfall, evaporation and runoff indices in the region. Further, uncertainties regarding this already high-risk natural environment are compounded by superimposing elements of potential climate change for a year 2050 scenario over the region.*

The following are some of the views that are discussed in the paper that are far removed from reality.

Figure 3d in the paper shows an increase in annual potential evaporation for the 2050 scenario for the whole of Botwana, Namibia and eastern Zimbabwe i.e. the area covered by the Kalahari sands, of **between 4% and 8%**. The GCMs used by Thomas et al (2005) discussed earlier in this report, predicted increases of **between 200% and**

400% for the same region. These order of magnitude differences in GCM outputs illustrate the fundamental shortcomings of global climate models. In both cases, it would have been a simple arithmetic exercise to determine historical trends based on real world data, and extrapolate them into the future.

The coefficient of variation (CV) is quoted several times in the paper to describe variability in the context of water resources. *'The inter-annual variability of precipitation, as measured by the coefficient of variation (CV,%) is an important consideration in water resource planning.'* This is an unacceptably simplistic characterisation of the statistical properties of rainfall and river flow. These properties are addressed in this report and its references.

In Fig. 4 (c) of their paper, they map the **drought risk index** as the ratio of the tenth percent to the fiftieth percent of the annual runoff. However, no relationship exists between drought risk and annual runoff, as the most important property of a drought is its duration.

In their Fig. 4 (d) they map a **flood severity index** as the ratio of the 50-year: 2-year, 1-day runoff. It is well known that the flood-producing runoff per unit area of a catchment decreases with increase in catchment area. The ratio between the 50-year and 2-year, 1-day unit runoff will vary along the length of a river and is not a regional characteristic. (See Alexander 2002, ***Statistical analysis of extreme floods***.)

A reduction in rainfall is predicted for the whole of South Africa by 2050. This is contrary to the IPCC scenarios as well as my observation of an increase in rainfall during the past 78 years. Rainfall will continue to increase as long as global warming increases, whatever the cause. This is another example of questionable GCM outputs that were not verified by comparison with real world observed data.

The resulting decrease in river flow by 2050 is equally questionable.

> *As a consequence mainly of anticipated changes in precipitation, the UKTR95 scenario for 2050 shows decreases in annual runoff of the order 0 - 40% over much of South Africa.*

This is a dramatic prediction with far reaching consequences. It was followed by an equally alarming prediction.

> *From a perspective of water resources management however, equally significant changes to those of mean annual runoff are increases of 10-20% in the interannual CV of runoff. These increases could add to the cost and complexity of managing water resources by requiring increased storage capacities as well as more stringent reservoir operating rules in regard to releases in dry years.*

Fortunately, there are no observational grounds to support these alarmist claims that are based solely on GCM predictions and questionable rainfall-runoff models.

The authors' conclusions are not surprising as they do not reference a single publication on hydrology or water resource development in South Africa, other than to publications from their own organisation, despite the numerous publications on this subject during the past 50 years right up to the present day. (For example Alexander 1985 ***Hydrology of low latitude southern hemisphere land masses*** and ***Management of the water resources of the Republic of South Africa*** issued by DWAF in 1986.)

No water resource practitioner would even remotely consider designing or operating water resource development projects based on GCM scenarios applied to simplistic rainfall-runoff model assumptions, particularly in the light of the availability of a wealth of routinely recorded data, and sound analytical methods based on advanced time series analyses, and not on primitive coefficients of variation.

9.5.15. Global warming will not increase poverty

> *In short, climate change will intensify the worst effects of poverty through losses in biodiversity, agriculture, health and almost every sector of society.* (DEAT 5 May 2005.)

The inclusion of 'poverty' is a typical alarmist tactic. Poverty is unrelated to these factors. The action required to counter the unavoidable and continued increases in greenhouse gas emissions will increase poverty, not reduce it.

9.6. The 1997/98 El Niño fiasco

In 1997 the World Meteorological Organisation issued dire warnings of the consequences of what was predicted as being the mother and father of all El Niños. Severe droughts were predicted for large areas of southern Africa. This prediction received widespread press publicity, and the governments of several southern African countries mobilized resources to deal with the forecast drought conditions.

In the event most of southern Africa received normal to above normal rains, but agricultural performance declined due to the cautious attitude adopted by many farmers. In Zimbabwe farmers, fearing the worst decided to minimize their losses by reducing the areas under staple food; diversifying to more drought resilient but less profitable crops; and resorting to wildlife farming. The maize production was reduced by 35% of the potential yield, and the nation was forced to import food for human and animal consumption. The Zimbabwe stock exchange reacted negatively to the news from the external press which resulted in fall of the value of stocks during the second half of 1997.

This false alarm severely damaged the credibility of climatologists and global climate forecast models.

9.7. No evidence of adverse changes

> *Evidence exists to suggest that variability and extremes in the southern parts of southern Africa may be increasing especially in the drier, western parts. Between 1931 and 1990, the intensity of extreme events has increased significantly over South Africa.* (Tyson and Gatebe 2001.)

It has been stated that signs of adverse climate changes have already been observed in South Africa. I have not found any in the hydrometeorological processes other than those described in this report. Nor have I seen any examples of postulated changes that have been subjected to rigorous analyses. Climate, as well as the natural environment that responds to it, are in a continuous state of flux on all time and space scales. As I have described in this report, it is a major and time-consuming exercise to distinguish between natural variability and variability that is the consequence of human activities. If undesirable changes are assumed to be present, then the question remains whether or not they are of sufficient magnitude to require incorporation in practical applications where most other components have uncertainties of the same order.

10. The remedies?

South Africa's report ***A national climate change response strategy for South Africa*** was submitted to the UN Conference of the Parties who signed the Kyoto protocol at Buenos Aires in December 2004. The following comments are on postulated actions required to reduce the impact of global warming that were proposed in the report. Regrettably they reflect a lack of knowledge on these issues.

10.1. Replacement of coal-fired power stations

The writers of the report were critical of the use of lower grade coal for power generation in South Africa.

The use of lower grade coal was criticised because of postulated greater emissions of dangerous greenhouse gasses. Visualise the following laboratory experiment. Burn a measured amount of pure carbon in a flask. The two products will be heat energy and CO_2. Now add some sand to the same amount of carbon and repeat the experiment. Exactly the same amount of CO_2 and heat energy will be produced. The inert sand will be a by-product. There will not be any increase at all in CO_2. Technology exists to trap any other noxious gasses that may be produced.

To suggest that South Africa should cease using lower grade coal because this contributes to global warming, demonstrates the researchers' lack of understanding, irresponsibility and careless disregard of the consequences to South Africa's economy. The costs involved in converting to other sources of energy, which will also be more expensive to electricity consumers, can be far better used to fight poverty, malnutrition and disease.

10.2. Better water resource management

This statement is offensive coming from those who have little experience in this subject. Refer to the comprehensive and well-illustrated book **Management of the water resources of the Republic of South Africa**, published by the Department of Water Affairs in 1986 and my extensive studies and reports.

10.3. Disaster management

It is the increased exposure to the consequences of natural phenomena that results in high loss of life and damage to property. This was tragically illustrated by the tsunami disaster in Indonesia and adjacent countries. There is no evidence to support the view that climate change will increase the frequency and magnitude of natural disasters. It is the vulnerability to these disasters that is increasing, not the magnitudes of the events themselves. I discuss this in detail in my report commissioned by the United Nations IDNDR secretariat titled ***Risk and society - an African perspective,*** (Alexander 1999).

10.4. Agricultural diversification

It is stated that South Africa is particularly vulnerable to climate change because a large portion of the country's agricultural production consists of maize farming. The document proposes that South African maize farmers should consider changing to other crops as long duration droughts will occur during the next three decades which will make maize farming unprofitable.

Let us have a closer look at this comedy of errors.

The statement that South African maize farmers should consider changing to other crops, as long duration droughts will occur during the next three decades, which will make maize farming unprofitable, is both false and irresponsible. Imagine the following scenario. As a result of the report farmers switch to sunflower seed production, which is more drought resistant. Maize, which is the staple food for tens of millions of people, has to be imported from overseas at a higher cost. Current sunflower seed producers face financial ruin as a result of the over-production of this commodity.

All of this is a consequence of the unfounded imagination of a few irresponsible scientists who flatly refuse to provide the basis for these alarmist views, so that they can be tested by others and exposed for what they are.

10.5. More energy efficient transport

Reduction in fuel consumption has long been a target of vehicle manufacturers. This will increase the cost of transport, particularly to the poorer communities who live far from their places of employment.

10.6. More energy efficient housing models

This is an absurd suggestion for South African conditions.

10.7. Technology transfer

The transfer of technology and skills from the developed to the developing nations was recommended. I have been closely involved in technology transfer for most of my career. There have been many well meaning but misguided recommendations based on the transfer of mild climate technology to arid climate conditions. This technical report is a good example of material that is new to science that comes from a developing nation. South African climate change scientists have made the mistake of blindly following northern hemisphere science and assuming that it is relevant to South African conditions without carrying out their own evaluations.

PART 3: SOCIO-ECONOMIC CONCERNS

11. Socio-economic aspects

The socio-economic aspects of climate change theory are even further removed from reality than the science itself. Once more, it is necessary that I establish my credentials.

In 1956 I was in charge of the construction of the large Floriskraal Dam on the Buffels River in the arid Karoo, 20 km downstream of the town of Laingsburg. In 1981 a severe flood occurred that destroyed Laingsburg and 104 lives were lost. Floriskraal Dam only suffered minor damages because of its ultraconservative design. I was appointed as a member of a Cabinet Advisory Committee to make recommendations on the reconstruction of the town. The principal reasons for the high loss of life were because the town was built on an ancient floodplain, the residents were unaware of the danger and there was no flood warning system. [Reference: ***Lessons learnt from the 1981 Laingsburg flood*** (Roberts & Alexander 1982)]

In 1993 I volunteered to assist with developing measures to relieve the plight of tens of thousands of people living in unplanned settlements that were vulnerable to flooding. There was a state of civil unrest and my first inspection of the Alexandra township was in an armoured vehicle escorted by troops. I reported that in some areas people were living in conditions that no citizens of this country should have to endure. I obtained funds from the university for the production and distribution of a booklet on mitigation measures using the position in Alexandra as an example. As a courtesy, I submitted my draft to the responsible government department. I was requested not to publish it because of the political implications.

The obvious solution was to re-house those in the most vulnerable areas elsewhere. The people refused to move, as they would not be in the vicinity of job opportunities, schooling and medical facilities. They considered that these advantages outweighed the disadvantages of unhealthy living conditions and flood risks. I developed a flood warning system, held courses for emergency personnel and produced comprehensive guidelines in my 560-page handbook ***Flood Risk Reduction Measures*** (2000a)**.**

In 2000 a tropical cyclone caused extensive damage and loss of life in Mozambique. As in Laingsburg, the high loss of life was due to the reluctance of the people living on the floodplains to abandon their homes. I was appointed as a member of an international team of experts to advise the government of the development of flood mitigation measures. I produced a report ***Structural and non-structural aspects of flood risk reduction*** (2000b).

I have other examples. There are several points that I wish to make. The first is that while the magnitude of the floods is important, it is the sociological aspects that are of greatest concern. The second is that during recent years there have been appreciable advances in reducing the consequences of these extreme events. The floods in South Africa during January and February this year, followed by two unusually severe tropical cyclones in Australia in March, resulted in minimal loss of life. The vulnerable populations were made aware of the risks and the emergency personnel reacted efficiently. Engineering measures have reduced the risks of failures of structures exposed to natural disasters.

Photographs of starving children in Africa accompanied by the claim that their starvation is the consequence of climate change are both opportunistic and false. They are starving because of prevalent poverty, malnutrition and disease, which in turn are the consequence of lack of resources, funds, knowledge and skills.

Even if the claims that global warming will lead to an increase in the frequency and magnitude of floods and droughts are valid, measures to avert the increases will have minimal effect on reducing the loss of life and livelihoods and damage to property. This is because these losses are more the result of the sociological conditions than the magnitude of the events. Affluent nations have greatly reduced the risks through the development of disaster mitigation measures. The poorer nations have a long way to go. Now climate change scientists and the political decision makers who believe them are propagating measures that will inevitably result in increased poverty, with all its adverse consequences, without any corresponding benefits.

This should be a matter of serious international concern.

12. Conclusions

This is an extremely serious situation. Alarmist claims are being made that are without foundation. If these alarmist views are correct, then South Africa will be in a very serious position in the years ahead, and we will almost certainly be heading into a recession with all that this implies for the prosperity of our nation. Why has no South African authority deemed it necessary to carry out independent studies, or appoint an independent commission of enquiry on such a grave issue?

In this report, I express my views on this very important subject based on a wealth of multidisciplinary experience and detailed studies.

My studies pose important questions regarding the reliability of global climate models and the theory on which they are based. These models are founded on simplistic views of the short and long-term characteristics of hydrometeorological time series, and the IPCC's rejection of the unequivocal linkages with variations in solar activity. Consequently, GCMs are inherently incapable of accurately describing past history and projecting it into the future.

Current climate change theory and the conclusions drawn from it are seriously in error. Governments that accept the IPCC's position should be aware of this. They should also carefully consider the sociological, economic and political consequences should they undertake costly and economically restrictive measures that are subsequently found to be based on erroneous science. Climate change scientists should also be aware of the potential harm to tens of millions of the poor and disadvantaged people of the world should their recommendations be implemented and later found to be in error. They should also consider the risks to their reputations and to those of science and scientists in general.

I am very confident of my conclusions.

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