

# Submission to Garnaut Climate Change Review

## Much more to the Earth's climate dynamics than human activity

Richard Mackey Canberra. \_\_\_\_\_

### ***Recommendations***

The scientific investigation of the Earth's climate dynamics examines all the factors that give rise to climate change. Policy advice about what a government might do ameliorate the impact of climate dynamics, or more realistically, adapt efficiently to expected impacts of climate dynamics, would have to have regard to all of the main classes of results of this scientific investigation.

If it didn't, the policy advice would be flawed.

If the Commonwealth Government was presented with a partial and biased analysis based merely on some aspects of climate dynamics, and policy advice was based only on a limited evaluation of some of those aspects, the legislative and budget measures implemented by the Commonwealth would join the catalogues of bad policy referred to in this Submission.

These considerations are relevant to Garnaut Climate Change Review.

If the Review focuses only on economic and financial measures to implement recommendations of the IPCC, the Review will be restricted to a range of possible measures linked a demonstrably unsound assessment of climate dynamics. As a result, the measures that the Review may recommend for the Commonwealth Government are destined to join that already long list of bad economic, financial and regulatory policies that now occupy far too much space in the pages of Commonwealth legislation, if the Government acted on the Review's advice. Furthermore, because the new measures would be based on bad policy, there would be substantial adverse consequences for Australia's adaptive efficiency.

That would be the Review's legacy.

### ***Recommendation No. 1***

In order that the Review might receive a disinterested overview of all the factors that give rise to climate change, I recommend that the Garnaut Climate Change Review arrange for a one day workshop on the twin themes of the science of climate dynamics and the shortcomings in the IPCC reports and processes. The Review should invite distinguished Australians with relevant expertise to present papers on these topics and invite members of the public to lodge submissions, as well.<sup>1</sup> The additional papers, the

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<sup>1</sup> For example, the Review might invite Don Aitkin, Professors Bob Carter, Ian Plimer and Stewart Franks and Mr John McLean to be the lead participants of the workshop.

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proceedings of the workshop and the report of the workshop authored jointly by the lead participants, would be a valuable addition to the material on the review's website.

### ***Recommendation No. 2***

That the Garnaut Climate Change Review bring to the Government's attention the widespread shortcomings/flaws in the IPCC assessments, reports and recommendations and in the Stern Report, and inform the Government that the science of climate dynamics:

- continues to publish findings about solar/climate relationships and internal variability of the climate system that invalidate the account of the Earth's climate dynamics presented by the IPCC;
- predicts the likelihood of an extended period of global cooling, if the emergent solar cycle 24 has a low amplitude, as seems increasingly likely on the basis of current science; and
- considers that large scale oscillations in our climate are the norm.

### ***Recommendation No. 3***

That the Garnaut Climate Change Review, having regard to the finding that large scale oscillations in our climate are the norm, advise the Government to implement policies that significantly strengthen Australia's adaptive efficiency.

### ***Recommendation No. 4***

That the Garnaut Climate Change Review advise the Government of the need for the Bureau of Meteorology, CSIRO and universities to resume research into the areas of relationships between solar variability and climate dynamics; the natural internal variability of the climate system; and relationships between climate dynamics and the massive re-engineering of the planet by human beings over the last 300 years or so.

### ***Recommendation No. 5***

That if the Garnaut Climate Change Review considers recommending new economic/financial measures such as taxes (direct or indirect), tax expenditures, subsidies, grants, economic transfers or other forms of assistance or industry and/or workforce regulation, and having regard to the finding of this Submission that such measures are not warranted by the science of climate change, the Review prefer measures that are as budget neutral as possible and have as little impact as possible on the adaptive efficiency of Australia's economy.

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### *Overview of Submission*

"Climate change", as a scientific concept, comprehends a far greater field of scientific inquiry than the examination of a change of climate attributable directly or indirectly to human activity.

Policy options for the Commonwealth Government about strategies to manage the effects of climate change must be informed by the science of the totality of climate change, not merely assessments of one possible factor. Government strategies based on a partial understanding of the problem to be addressed invariably result in bad policy.

The science of climate dynamics is a relatively new area of scientific inquiry. It examines a system of immense complexity for which the sets of available valid and reliable measures are limited in scope and time spans covered. The main subsystems, the oceanic/atmospheric oscillations; the Sun; the four dimensional structures of the oceans and atmospheres; clouds; and the interaction of the components of the atmosphere, the oceans and the Sun are also immensely complex, poorly understood and poorly modelled.

Apart from the theory of human activity as a source of climate change, there are three main theories that aim to explain the Earth's recent climate dynamics. These three theories explain the Earth's climate dynamics in terms of total solar variability;<sup>2</sup> the natural internal variability of the climate system; or in relation to the massive re-engineering of the planet by human beings over the last 300 years or so. More comprehensive theories might include all factors.

This Submission provides a summary of recently published science about the relationship between variable solar activity and the Earth's climate dynamics.

This research, which is based on observation, analysis and the evaluation of theories capable of corroboration or falsification rather than the difficult to falsify IPCC computer simulations, documents increasingly well established relationships. Unlike the IPCC's approach, the solar/climate research considers the non-linear, non-stationary nature of the climate system.

Total solar variability affects the Earth's atmosphere differentially in relation to both time and space. The overall effect of total solar variability means that some regions of

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<sup>2</sup> Total solar variability refers to solar variability of all types: irradiance, matter, electromagnetic and gravitational fields and the changing geometric topology of the Sun/Earth and Sun/Earth/Moon relationships and the interactions between all five.

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the Earth cool, others warm; some dry out, others become saturated; some flattened by devastating winds, others subject to gentle zephyrs.

The impact of total solar variability on the climate system is highly complex, dynamic and differential. The system contains numerous non-linear, non-stationary processes that interact throughout the system's four dimensional structure. The non-linear non-stationary processes amplify small solar effects and may operate in contrary directions, some cooling, and some warming.

Joan Feynman, one of the world's leading astrophysicists, concluded (Feynman (2007))<sup>3</sup>:

*There are now many empirical and modelling studies that demonstrate that changes in the solar output are associated with widespread changes in climate. The development of quantitative models and a physical understanding of all the underlying mechanisms involved is currently a rapidly developing field of study. There is considerable evidence that climate variations in response to low frequency solar variations have had major effects on cultures during the last 1,500 years.*

According to Feynman (2007), there is now general recognition within the scientific community that the traditional definition of "climate change" in terms of the global average temperature was too restricted to be useful for an understanding of the response of the Earth's surface to changes in the climate drivers. For example, low solar output results in a cold region that extends across northern Europe and Asia. However, it also results in a warm anomaly off the south-west coast of Greenland. At the same time, Northern Africa and the Middle East will remain warm, while the temperatures in the western United States will be largely unaffected.

Feynman (2007) found that, in response to variable solar activity, the real change in global average temperatures has been smaller than the change in the regional temperatures. Significantly, it was the regional temperatures that have influenced human history.

Alexander Ruzmaikin, also an astrophysicist with NASA, considered that the impact of solar variability is to change the probability of the duration of particular climate patterns associated with cold conditions in some regions and warm conditions in other regions. These consequences are far more important, he argues, than changes to average global temperatures (Ruzmaikin (2007)).

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<sup>3</sup> Joan Feynman is an astrophysicist with NASA's Jet Propulsion Laboratory. In 1999 she was named as one of JPL's elite senior scientists and in 2000 was awarded NASA's Exceptional Achievement Medal.

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The evidence reviewed in this Submission shows that low amplitude solar activity cycles generally result in a cooler global climate. Two or more such cycles in succession usually result in severe cooling. In the past such sequences have induced cold epochs referred to as little ice ages. There is increasing evidence that the emergent solar cycle 24 will be low amplitude and followed by one or two more low amplitude cycles.

These conclusions are at best indicative and subject to substantial additional scientific inquiry. However, they are no more speculative or uncertain than the IPCC's projection of global warming. In contrast to the IPCC's work, they are based on direct observation and scientific analysis.

This Submission also highlights new findings being established by the statistical theory of non-linear, non-stationary time series. All time series of climate and geophysical phenomena are of this type. The IPCC ignored this knowledge and used time series analysis statistical methodologies that assume the time series are linear and stationary. The IPCC has ignored the established statistical methodology that has been in the text books for at least 20 years. Two of the world's leading statisticians who reviewed a large volume of geophysical and climate science papers on which the IPCC relied, came to this conclusion in their 2005 paper ((Cohn and Lins (2005)). Whilst the core of Cohn and Lins rather technical paper is mathematical and statistical analysis, their overall conclusion is sombre:

*These findings have implications for both science and public policy. For example, with respect to temperature data, there is overwhelming evidence that the planet has warmed during the past century. But could this warming be due to natural dynamics? Given what we know about the complexity, long-term persistence, and non-linearity of the climate system, it seems the answer might be yes. Finally, that reported trends are real yet insignificant indicates a worrisome possibility: Natural climate excursions may be much larger than we imagine. So large, perhaps, that they render insignificant the changes, human-induced or otherwise, observed during the past century.*

Dr Murray Peel and Professor Tom McMahon, of the Dept of Civil and Environmental Engineering Melbourne Uni., have recently shown that randomness in the climate system has been on the rise since the 1950s (Peel and McMahon (2006)). They argued the long term memory of the climate system is shortening, thus increasing the degree of randomness in the system.

The conclusions about the likely development of the Earth's climate system over the next several decades indicate a heightened need for government's to maximise to the extent possible, the adaptive efficiency of their national economic systems. The IPCC

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predicts that the planet will warm considerably; solar/climate research that it will probably cool significantly, whereas statistical theory predicts that large scale oscillations in our climate are the norm. The evidence is that the climate system is becoming more random.

In his many publications, for example North (2005), Douglass North stressed that if the issues with which we are concerned, such as global warming and the global commons, belong in a world of continuous change, that is, a non-ergodic world, then we face a set of problems that become exceedingly complex.<sup>4</sup> North emphasised that our capacity to deal effectively with uncertainty is essential to our succeeding in a non-ergodic world. History shows that regional effects of climate change are highly variable and that the pattern of change is highly variable. An extremely cold (or hot) year can be followed by extremely hot (or cold) year. Warming and cooling will be beneficial for some regions but catastrophic for others.

Fagan (1999, 2000, and 2004) documented in detail the relationships between the large scale and generally periodic changes in climate and the rise and fall of civilisations, cultures and societies since the dawn of history. He has shown that over the past 5,000 years catastrophic climate change has destroyed governments, societies and civilisations that could not adapt efficiently. The thesis of this paper is that the Sun, through its relationships with the solar system, is largely responsible for these changes and that we are now on the cusp of one of the major changes that feature in the planet's history. Fagan (2004, page xv) concluded: *The whole course of civilisation .... may be seen as a process of trading up on the scale of vulnerability.* We are now, as a global community, very high up on that scale.

As Douglass North showed, the main responsibility of governments in managing the impact of the potentially catastrophic events that arise in a non-ergodic world, is to manage society's response to them so as to enable the society to adapt as efficiently as possible to them. Amongst other things, this would mean being better able to anticipate and manage our response to climate change, minimise suffering and maximise benefits and the efficiency of our adaptation to a climate that is ever changing, sometimes catastrophically, but generally predictably within bounds of uncertainty that the statisticians can estimate, but only by having regard to the scientific investigation of the Earth's climate dynamics that examines all the factors that give rise to climate change.

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<sup>4</sup> North explained that an ergodic phenomenon has an underlying structure so stable that theory that can be applied time after time, consistently, can be developed. In contrast, the world with which we are concerned is continually changing: it is continually novel. Inconsistency over time is a feature of a non-ergodic world. The dynamics of change of the processes important to us are non-ergodic. The processes do not repeat themselves precisely. He argued that although there may be some aspects of the world that may be ergodic, most of the significant phenomena are non-ergodic.

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### ***Introduction***

The Review's terms of reference speak as if the terms "human induced climate change" and "climate change" are interchangeable.<sup>5</sup> The United Nations Framework Convention on Climate Change (UNFCCC) defines (in its Article 1) 'climate change' as: '*a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods*'. Thus the IPCC definition of climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer) arising only from human activity.

The scientific examination of climate change considers climate dynamics in totality, inquiring into all reasons for the Earth's climate dynamics. These include theories that explain the Earth's climate dynamics in terms of solar variability; in terms of the natural internal variability of the climate system; or in terms of the consequences of the massive re-engineering of the planet by human beings over the last 300 years or so (Cotton and Pielke, 2007). More comprehensive theories might include all of these factors.

The disinterested approach of science formulates theories and proceeds to produce evidence and analysis that corroborates or refutes existing theories. Science thrives on doubt, debate, the production of conflicting evidence and analysis and the advancement of theories of greater and greater explanatory power, covering broader classes of phenomena and longer time frames. Science is forever uncertain, rarely settled. In an area as complex and as young as the science of climate dynamics, the statement that "the science is settled" and the like will always be false.

This submission outlines for the Review relatively recent evidence for explanations of the Earth's climate dynamics based on variations in the activity of the Sun, noting that there is substantial evidence that solar variability of all types - irradiance, matter, electromagnetic and gravitational force and the changing geometric topology of Sun/Earth relationship and the interactions between all five - play a key role in the Earth's climate dynamics.<sup>1</sup>

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<sup>5</sup> The Review's first term of reference refers to "The likely effect of human induced climate change on Australia's economy, environment, and water resources"; the Review's second term of reference refers to "The possible ameliorating effects of international policy reform on climate change"; the Review's terms of reference also state "In making these recommendations, the Review will consider policies that: mitigate climate change, reduce the costs of adjustment to climate change (including through the acceleration of technological change in supply and use of energy), and reduce any adverse effects of climate change and mitigating policy responses on Australian incomes".

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### *Catalogues of bad Commonwealth policy.*

Amongst current Commonwealth legislation and the budgets of previous Commonwealth governments there is an abundance of measures, including taxes (direct and indirect), tax expenditures, subsidies, grants, economic transfers and other forms of assistance or industry and/or workforce regulation about business risks and market failures<sup>6</sup> resulting in wasteful, inefficient and ineffective expenditure, taxes, transfers, and the like and damaging impacts on society.

These are periodically detailed in reports, some commissioned by the Government of the day. The first of these, and perhaps the most comprehensive, was undertaken by in 1974 by Dr H. C. Coombs at the request of the Whitlam Government<sup>7</sup> However, there have been others since then.

These reports detail policies and could form a textbook of government failure. They catalogue the extent of bad Commonwealth economic and financial policy written into Commonwealth legislation and budgets by successive governments over many generations. Examples include policies that

- serve vested interests who succeeded in capturing the ear of the government of the day;
- based on sometimes ill-considered, but often down-right false, theories about the measures and their effectiveness;
- respond to the noisy calls of populist movements against the best advice available to the government at the time;
- are too difficult politically for governments to remove even though the policies are known to be wasteful, damaging and a drain on economic activity.

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<sup>6</sup> Legislation and administrative discretions permit the Commonwealth to incur a range of Commonwealth contingent liabilities that provide some form of risk protection of mitigation to the private sector. This category of contingent liabilities may result in a Commonwealth liability and can impede competitive neutrality in the market place. This category includes all those instances in which the Commonwealth enters into a transaction with another party according to which the Commonwealth incurs a contingent liability as a result of, for example, of issuing a loan, underwriting a risk, acquiring a financial obligation or contingent liability provided for under legislation, deeds, contracts, or correspondence. Examples include: loans, trade insurance, and the provision of Commonwealth guarantees, indemnities and the like. See further *The Management of Commonwealth Guarantees, Indemnities and Letters of Comfort* Auditor-General's Report No. 47 of 1997/98 tabled in the Commonwealth Parliament on 23 June 1998. See [http://www.anao.gov.au/uploads/documents/1997-98\\_Audit\\_Report\\_47.pdf](http://www.anao.gov.au/uploads/documents/1997-98_Audit_Report_47.pdf)

<sup>7</sup> Task Force to Enquire into the Continuing Expenditure Policies of the Previous Government [Coombs Committee] 1973, *Review of the Continuing Expenditure Policies of the Previous Government* AGPS Canberra.

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A good way to ensure that futures policies do not add to the existing long list of bad policy is to conduct a sound evaluation of the full range of possible policy measures to address problems that the Commonwealth may be called upon to solve, especially where calls for Commonwealth measures arise from the concerns listed above. Amongst other things this requires that the Commonwealth consider a comprehensive overview of the problem and that the range of measures being considered be subject to a sound cost benefit evaluation of all relevant options.

For example, the Commonwealth may quite sensibly be asked to implement policies to ameliorate unemployment. However, a Government that only considered unemployment as caused by human capital shortcomings and therefore only considered policy options that addressed human capital improvement strategies would be roundly condemned by all. Such an approach would be rightly recognised as narrow and unsound, as the causes of unemployment are multivariate, complex, operate on different time scales and are connected to a wide range of other economic, financial and social policies, requiring a wide range of sometimes interdependent strategies. These could range from strategies dealing with the exchange rate through to education.

### *IPCC policy advice flawed by design*

The United Nations Framework Convention on Climate Change (UNFCCC) defines (in its Article 1) 'climate change' as: '*a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods*'. Thus the IPCC definition of climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer) arising only from human activity.

At the time this was being formulated and ratified there was extensive evidence pointing to other explanations of climate variability. Variable solar activity as a driver of climate variability has been the subject of detailed study for more than a century. Variations in the complex variable gravitational fields of the Sun, the Moon and the earth (giving rise to the familiar experience of the lunisolar tides was another area. Other teams of scientists were examining the internal variability of complex climate dynamics. There was also an increasing awareness that the massive re-engineering of the planet during the last 300 years could change our climate. The greenhouse gas hypothesis was considered to be one of the more marginal explanations at the time.

But the IPCC was set up only to examine human induced climate variability. It could not proceed in a scientific manner to examine climate variability. A scientific inquiry would begin with the base case and evaluate the full range of plausible explanations.

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The IPCC has not examined with the scientific rigor expected of a scientific inquiry the main extant alternative explanations of climate variability. The IPCC has not placed before world governments the evidentiary force of these explanations as might be expected of a scientific inquiry. The IPCC has not given a professional, disinterested scientific account of natural climate variability. In contrast, scientists have shown beyond reasonable doubt that the IPCC has deliberately minimised natural climate variability during the 20<sup>th</sup> Century and all preceding centuries.

In contrast, and in an entirely anti-scientific, as against, non-scientific, manner, the IPCC has denigrated alternative explanations, has sought to vilify valid scientific explanations, and personally attack with a view to silencing scientists and others who present valid scientific explanations. Is this the hallmark of a disinterested scientific inquiry into the truth about climate change? No; it is the footprint of an uncompromising ideological agenda. A recent example of the ideological, rather than scientific, *modus operandi* of the IPCC is the highly political and dismissive way in which the IPCC responded to the advice offered to it by two distinguished (and retired) experts, Ian Castles a Visiting Fellow at the Asia Pacific School of Economics and Government at the Australian National University, an economist and statistician, a former head of Australia's Bureau of Statistics; and David Henderson, the former chief economist of the Organisation for Economic Co-operation and Development and now visiting professor at Westminster Business School.<sup>8</sup>

Furthermore, as other submissions to this Review will describe, there are serious and basic flaws in the IPCC's account of the hypothesised role of human activity in the Earth's climate dynamics.

The Productivity Commission's recent working paper identified correctly the extent of exaggeration and distortion of analysis, policy and strategy in the Stern Report.<sup>9</sup>

The reports of the IPCC and the measures the IPCC recommend are even more extreme in their misstatements of problems, issues, explanations and measures.

The IPCC is a political lobby group that understates alternative explanations, belittles alternative perspectives, tries to stifle debate, is authoritarian and

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<sup>8</sup> An account of this can be found on the websites <http://www.onlineopinion.com.au/view.asp?article=2147> and <http://www.lavoisier.com.au/papers/articles/IPPCissues.html>

<sup>9</sup> The Stern Review: as assessment of its methodology, Staff Working Paper, Productivity Commission, January 2008

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belligerent in its dealing with critics; the IPCC shamefully exaggerates its own agenda.

Similarly, a sound explanation for the Earth's climate dynamics has to take into account all the key science being published by the scientific community. The sound explanation should therefore take into account variable solar activity; variations in the complex variable gravitational fields of the Sun, the Moon and the Earth; the internal variability of the immensely complex climate system; and the role of the massive re-engineering of the planet during the last 300 years.

#### *The Sun's role in climate dynamics*

The impact of the Sun on the Earth's climate has been an active area of scientific inquiry ever since Sir William Herschel presented a series of papers on the subject to the Royal Society in London in 1801. He hypothesised a relationship between solar activity and the 562 year time series of wheat prices (from 1202 to 1764) in Adam Smith's *The Wealth of Nations* that was published twenty-five years earlier in 1776. See **Attachment 1 Sir William Herschel and the Royal Society**.

Research published in the last five years shows that the Sun has had a much greater role in generating climate change from the last century to the present time than previously considered possible. This research has also documented the considerable evidence that solar variability has been the key driver of climate change for millennia.

Solanki and Krivova (2004a) and (2003b) found that the Sun has been more active in the last seventy years than at any time for over 8,000 years. Whilst this indicates that the high level of solar activity in recent years is exceptional, it is not unique on the multi-millennial time scale. Solanki et al (2004) found that during the last 11,400 years, the Sun spent only 10 percent of the time at a similarly high level of activity.

That the modern high level of solar activity is unusual has been confirmed for the last 7000 years by an analysis of the new reconstruction of the palaeomagnetic dipole moment by Korte and Constable (2005). Usoskin, Solanki and Korte (2006) found that according to this reconstruction, the Sun was in a strongly active state, similar to the modern high activity episode with the decadal sunspot number systematically exceeding 70, only about 3% of the time during the last 7000 years.

Solanki et al (2004) and (2005) and Solanki and Krivova (2004a) and (2004b) reported that most of the warming of the twentieth century has occurred during two periods, from about 1910 to the mid 1940s and from the mid 1970s onwards.

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Rozelot and Lefebvre (2006) found that solar irradiance variability accounted for a significant proportion of the trend in global temperatures in the periods 1856–1910, 1910–1945 and 1946–1975.

Scafetta and West (2006a and 2006c) estimated that the increase of solar irradiance during the 20<sup>th</sup> century might be responsible of approximately 50% of the global warming. However, they report that this contribution was not uniform during the century. Scafetta and West (2006a and 2006c) found that the sun might have contributed 75% of the global warming during the first half of the century (1900-1950) but only 30% during the second half of the century (1950-2000). Their findings confirm that the Sun played a dominant role in climate change in the early past, as several empirical studies had also found. Willson and Mordvinov (2003) reported that the analysis of the data about sunspot activity provided by six overlapping satellite observations since 1978 shows that total solar radiation output had increased by approximately 0.05 per cent per decade.

Labitzke (2007, 2006) reviewed many relevant and recent reports of research published in the scientific literature.

In her overview, Labitzke (2007) notes:

*The relatively weak, **direct** radiative forcing of the solar cycle in the upper stratosphere can lead to a large **indirect** dynamical response in the lower atmosphere through the modulation of the polar night jet as well as through a change in the Brewer Dobson Circulation.*

She explained further that:

*Until recently it was generally doubted that the solar variability in the 11-year sunspot cycle (SSC), as measured by satellites, has a significant influence on weather and climate variations. But several studies, both empirical and modelling, have in recent years pointed to probable and certain influences. Different observations indicate that the mean meridional circulation systems, like the Brewer-Dobson Circulation and the Hadley Circulation are influenced by the 11-year solar cycle. Today, there is general agreement that the direct influence of the changes in the Ultra-Violet part of the spectrum (6% to 8% between solar maxima and solar minima) leads to more Ozone and warming in the upper stratosphere (around 60 km) in solar maxima. This lead to changes in the thermal gradients and thus in the wind systems, which in turn lead to changes in the vertical propagation of the planetary waves that drive the global circulation.*

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She stated:

*Based on observations, the results presented demonstrate conclusively the existence of a signal of the 11-year sunspot cycle in the stratospheric and tropospheric temperatures and heights.*

Her own research published over a twenty year period shows that the Quasi-Biennial Oscillation is regulated by variable solar activity and that the Sun influences the intensity of the Arctic Oscillation in the stratosphere in winter.

This continuing increase in solar output since the 1850s has warmed the oceans, releasing Carbon Dioxide and water vapour.

The time series of total solar variability, like those of climate variability, are non-stationary, in that the measures within each are interrelated, and non-linear. When analysed using a statistical methodology specially designed to analyse non-stationary and non-linear data, the role of the Sun in regulating the climate is shown clearly and at statistically significant levels. Empirical Mode Decomposition (EMD) is such a statistical methodology (Huang et al (1998)). EMD, unlike most statistical methodologies for analysing time series, makes no assumptions about the linearity or stationarity of a time series. EMD lets the data speak more directly, revealing its intrinsic functional structure more clearly. It does not have the restrictive assumptions of linearity and stationarity that the familiar Fourier-based techniques have, because it uses Hilbert, not Fourier, transforms.

Using EMD, Coughlin and Tung (2005, 2004a, 2004b and 2001), found that the atmosphere warms during the solar maximum and cools during solar minimum almost everywhere over the planet. The statistically significant correlation with the solar flux is positive everywhere over the globe does imply that, on average, the temperatures increase during solar maxima and decrease with solar minima at all latitudes. Coughlin and Tung (2005, 2004a, 2004b and 2001) also found two underlying nonlinear trends over the last four decades. One is the warming of troposphere; the other is the cooling of the stratosphere.

Ruzmaikin, Feynman and Yung (2006) used EMD to analyse the historic time series annual records of the water level of the Nile collected in 622-1470 A.D. (This famous time series is discussed below on page 24, especially end note viii). They found the longer solar periodicities of about 88 years and one around 200 years. These are characteristic solar periodicities. For example, they are present in the number of auroras reported per decade in the Northern Hemisphere at the same time. They found the 11-year solar cycle in the Nile's high-water level variations, but less prominent in the low-

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water anomalies. Ruzmaikin, Feynman and Yung (2006) explained that the phenomena they report would arise from the influence of solar variability on the atmospheric Northern Hemisphere Annular Mode (NAM). Solar Ultra-Violet variations act in the stratosphere to modulate the NAM. Furthermore, the NAM's sea level manifestation (the North Atlantic Oscillation) affects the air circulation over Atlantic and the Indian Oceans during high levels of solar activity. Variations of this air circulation influence rainfall in eastern equatorial Africa at the Nile sources. At high solar activity, the air is descending there and conditions are drier, with the opposite effect occurring at low solar activity.

Camp and Tung (2007a and 2007b) established for the first time by direct measurement that the Sun heats the Earth directly.<sup>ii</sup> They obtained a statistically significant global warming signal of almost 0.2°K due to the 11 year solar cycle.

Camp and Tung (2007a and 2007b) also revealed the surface pattern of warming caused by the Sun. Amongst other things, polar amplification is shown clearly with the largest warming in the Arctic (treble that of the global mean), followed by that of the Antarctic (double). Surprisingly, the warming over the polar region occurs during late winter and spring.

The warming is also larger over continents than over the oceans. In the mid-latitudes, there is more warming over the continents than over the oceans. Most of Europe is warmed by 0.5°K and eastern Canada by 0.7°K, while western U.S. sees a smaller warming of 0.4-0.5°K. Iraq, Iran and Pakistan are warmer by 0.7°K and Northern Africa by 0.5°K. The South American Andes is colder by 0.7°K.

They derived a statistically significant measure of the range climate sensitivity (of 2.3°K to 4.1°K) to the variations in the 11 year solar cycle. It is independent of climate models as it is the result of direct measurement. The climate sensitivity lower bound is equivalent to a global warming of 2.3°K at doubled Carbon Dioxide.

Salby and Callaghan (2006) established that there is a decadal oscillation in the tropical troposphere that depends on the 11-year oscillation of solar irradiance. They found this occurred over the four solar cycles analysed. The statistical analysis achieved higher levels of statistical significance that had been previously required.

Gleisner et al (2005) found that statistically significant variations in tropospheric temperatures, geopotential heights, water vapour distribution and global circulation regimes in phase with the solar cycle over the last 44 years. The authors established that

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there is a statistically significant consistent pattern of atmospheric response to solar variability throughout the low- and mid-latitude troposphere.

Some of the research about Sun-climate connections published in the 1970s and before lacked statistical rigour. As a result, some scientists published explanations of the Earth's climate dynamics in terms of solar variables that did not stand up to statistical rigour (Pittock 1978, 1983). In addition, sometimes some scientists published claims for a significant role of the Sun in inducing major climate change that could not be sustained when subject to rigorous statistical and methodological scrutiny (Damon and Laut (2004), Laut (2003).

Bond et al (2001) demonstrated that:

*The Earth's climate system is highly sensitive to extremely weak perturbations in the Sun's energy output, not just on the decadal scales that have been investigated previously, but also on the centennial and millennial time scales documented here.*

Furthermore, the authors concluded:

*Our findings support the presumption that solar variability will continue to influence climate in the future, which up to now has been based on extrapolation of evidence from only the last 1,000 years.*

Bond et al (2001) tested the solar-climate connection by comparing high-resolution measurements of drift ice in three North Atlantic deep-sea cores with proxies of changes in solar irradiance through the entire Holocene. Their analyses imply the footprint of the solar impact on climate extended from polar to tropical latitudes. Amongst other things, the authors found five episodes of markedly reduced rainfall at times of very weak solar minima centered on 6 300, 7 400, 8 300, 9 000 and 9 500 years ago. Their analyses imply that at times of reduced solar irradiance, the downward-propagating effects triggered by changes in stratospheric Ozone lead to a cooling of the high northern latitude atmosphere, a slight downward shift of the northern tropical jet, and a decrease in the Northern Hadley circulation.

Haigh (2006) reviewed many recently published papers about solar influence on the atmosphere. She concludes:

*Multiple regression analysis of zonal mean temperature records from the forty-year reanalysis datasets produced by the US National Center for Environment Prediction and the European Center for Medium-Range Weather Forecasts has revealed a detectable 11-*

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*year solar signal in the troposphere. These show bands of warming in the mid-latitudes when the Sun is more active suggesting a latitudinal widening of the Hadley cells. Careful analysis of upper air data dating back eighty years has broadly confirmed these findings. Furthermore, the patterns identified are similar to those predicted by atmospheric GCMs for the influence of enhanced solar UV, thus tending to confirm the existence of such an influence of the Sun on the climate.*

Bronnimann et al (2006) concluded that studies based on data from the past 25-45 years show that irradiance changes related to the 11 year solar cycle affect the circulation of the upper troposphere in the subtropics and mid-latitudes.

More generally, they concluded:<sup>iii</sup>

*Our analysis of the relation between solar irradiance variability and zonal mean geopotential height at midlatitudes during the past 82 years reveals an 11 year signal (increasing geopotential height with increasing solar variability) that is consistent with previous studies based on much shorter periods.*

Bronnimann et al (2006) reported that while solar impact on climate is increasingly well accepted in the scientific community, the processes that produce it are not.

Stager, Ruzmaikin et al (2007) concluded that there is no doubt that solar irradiance plays a central role in establishing the rhythm of diurnal, seasonal, and orbital-scale climate cycles. They reported that solar irradiance drives convection and migrations of the Intertropical Convergence Zone. They showed that significant relationships between the solar cycle and rainfall existed in East Africa during the 20th century. Stager, Ruzmaikin et al (2007) demonstrated how sunspot cycles could be used to predict positive regional rainfall anomalies several years in advance. They recommended that this knowledge be used to improve the circumstances of people, having regard to the serious consequences that heavy rains in East Africa have for soil erosion, hydropower generation, flooding, and insect-borne disease, and that they can also affect regions farther north that respond to the ebb and flow of the Nile.

Feynman (2007) reported that

*There are now many empirical and modelling studies that demonstrate that changes in the solar output are associated with widespread changes in climate. The development of quantitative models and a physical understanding of all the underlying mechanisms involved is currently a rapidly developing field of study. There is considerable evidence*

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*that climate variations in response to low frequency solar variations have had major effects on cultures during the last 1,500 years.*

Haigh (2007) reviewed some of the evidence for a solar influence on the lower atmosphere. She discussed some of the processes by which the Sun may produce more significant impacts than might be surmised from a consideration only of variations in total solar irradiance. Her paper is published in a new on-line peer reviewed scientific journal, *Living Reviews of Solar Physics*, which enables the paper to evolve as others contribute new material or engage in additional analyses of her commentary. Her paper is a good example of careful science in which analyses and findings are presented with the understatement of cautious science working to the high standards of the exact sciences such as Physics.

Haigh (2007) reviewed some of the science summarised in this paper, but in much more detail. She also surveyed many papers not cited in this paper. She presented many tentative findings throughout her paper including the following:

*There is statistical evidence for solar influence on various meteorological parameters on all timescales, although extracting the signal from the noise in a naturally highly variable system remains a key problem. With regard to the climate, further data-mining and analysis are required to firmly establish the magnitude, geographical distribution and seasonality of its response to various forms of solar activity.*

The strength of the Interplanetary Magnetic Field (IMF) generated by the Sun varies with the solar cycle.<sup>10</sup> This generates a variety of climate effects. As a result of recent

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<sup>10</sup> The Sun has two immense structures that extend throughout the solar system. They are the Interplanetary Magnetic Field (IMF) and the Heliospheric Current Sheet (HCS). The IMF is the extension, by the solar wind, of the Sun's magnetic field. The solar wind carries the IMF into interplanetary space, fixing magnetic field lines as it does so. The IMF travels outward into interplanetary space in a spiral pattern like a Catherine Wheel. The polarity of the IMF in the Sun's northern hemisphere is opposite to its polarity in the southern hemisphere. These polarities reverse with each solar cycle. The solar wind and its embedded interplanetary magnetic field (IMF) buffet the Earth's magnetosphere resulting in continuous geomagnetic activity, waxing and waning with the changing wind. The complex phenomenon of geomagnetic activity is described by "geomagnetic indices". Different indices respond with different sensitivities to different parameters of the solar wind; some are most sensitive to changes in the magnetic field; some are more sensitive to the solar wind speed. The HCS is a thin current sheet that separates the oppositely directed open field lines of the IMF that run parallel to each other along the plane of the Sun's magnetic equator. The HCS has a wavy, ballerina skirt-like structure as it extends into interplanetary space, filling the heliosphere. This is because of an offset between the Sun's rotational and magnetic axes and a warp caused by the quadrupole moment in the solar magnetic field. (The quadrupole moment is the standard measure of the extent to which the shape of a curved object departs from that of a perfect sphere. In relation to the IMF, it is a measure of the degree to which the shape of IMF is not spherical, but nevertheless curved). Sometimes the Earth is above and sometimes below the rotating HCS. As a result, it

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research involving international collaboration between Australian scientists in the Antarctic Division (Burns et al (2007)), IMF variability has been shown to vary the global electric circuit resulting in climate change.

This is an important finding as it shows how a series of small Sun-sourced changes amplify each other, bring significant changes to the global electric circuit, changing climate as a result. These changes in turn affect atmospheric pressure, cloud formation, rainfall and atmospheric temperature. The small Sun-sourced changes include some that depend on the Sun-Earth geometry and can therefore be calculated with sufficient precision. These are the Earth's periodic intersection with the Heliospheric Current Sheet and particular orientations of the Sun and the Earth to each other. They also include variations in the solar cycle, the strength of the solar wind, the incidence of Solar Proton Events.

Total solar variability affects the Earth's atmosphere differentially in relation to both time and space. The overall effect of total solar variability means that some regions of the Earth cool, others warm; some dry out, others become saturated; some flattened by devastating winds, others subject to gentle zephyrs.

The impact of total solar variability on the climate system is highly complex, dynamic and differential. The system contains numerous non-linear processes that interact throughout the system's four dimensional structure. The non-linear processes amplify small solar effects and may operate in contrary directions, some cooling, and some warming.

de Jager (2005) concluded that the role of the Sun is significant, but as it depends on latitude and longitude, it is incorrect to hypothesise a uniform measure of the Sun's impact on the Earth's surface. de Jager (2005) reported that never during the last 10,000 years has the Sun been as active in ejecting magnetised plasma as during the last few decades. He noted that the maximum level of solar activity may have passed recently and that solar activity may continue to decrease in coming decades.

Versteegh (2005) reviewed the many difficulties in the way of interpreting Sun-climate relationships. He noted the variable nature of Sun-climate relationships in relation to latitude and longitude and that the Sun induces a non-linear response at any given location. Versteegh (2005) noted that this complicates the assessment of Sun-climate relationships and requires the nonlinear analysis of multiple long and high resolution records at the regional scale. He reported that the field of non-linear analysis of Sun-

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experiences regular, periodic changes in the polarity of the IMF. The connection of the Earth to these two structures means that the Earth is immersed in the Sun, even at the distance of 150 million kilometres.

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climate relationships is somewhat underdeveloped even though the dynamics major climate configurations such as ENSO, NAO and the AO are nonlinear. He considered that more research is required to establish relationships between the lunisolar tides, geomagnetism and climate.

Ruzmaikin (2007) explained that linear and non-linear systems respond differently to external forces. The response of linear system is simply linearly proportional to the applied external force. Non-linear systems respond in a conceptually different way. Non-linear systems have internally defined preferred states known mathematically as attractors.

The response of non-linear systems to an external force is variable residency in the preferred states (i.e. the attractors) and changes in the transitions between them. The issue is not a magnitude of the response to an external force, as with the response of linear systems, but one or more of:

- a change of state;
- a change in the time spent in different states; and/or,
- the rate of oscillation between states.

Ruzmaikin (2007) considered that the impact of solar variability is to change the probability of the duration of particular climate patterns associated with cold conditions in some regions and warm conditions in other regions. These consequences are far more important, he argues, than changes to average global temperatures.

According to Kovaltsov and Usoskin (2007), the Earth's climate is not formed or modulated uniformly over the planet. It is largely determined by conditions in some specific key regions. These, in turn, affect larger regions or global climate features. They argued that the global climate can be affected via changes of not only global atmospheric or ocean parameters, but also via local changes if related to such key regions. Kovaltsov and Usoskin (2007) explained that regional variations, which have a solar origin, overlay the temporal variations in the amount of solar irradiance, which at any location on Earth, are synchronous all over the planet.

According to Feynman (2007), there is now general recognition within the scientific community that the traditional definition of "climate change" in terms of the global average temperature was too restricted to be useful for an understanding of the response of the Earth's surface to changes in the climate drivers. For example, low solar output results in a cold region that extends across northern Europe and Asia. However, it also results in a warm anomaly off the south-west coast of Greenland. At the same time,

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Northern Africa and the Middle East will remain warm, while the temperatures in the western United States will be largely unaffected.

Feynman (2007) found that, in response to variable solar activity, the real change in global average temperatures has been smaller than the change in the regional temperatures. Significantly, it was the regional temperatures that have influenced human history.

There may also be phase synchronisation between gravitational (i.e. tidal) and solar periodicities and between several atmospheric/oceanic oscillations (Tsonis, Swanson and Kravtsov (2007)). Benegtsson (2006) demonstrated that the climate system has a high level of intrinsic variability. He showed that significant climate variations in many parts of the world on various time scales are due to internal processes. Delworth and Knutson (2000) found that very small differences in the initial conditions of computer simulations of climate can result in large variations later that are much like the climate changes we have observed this century.

Delworth and Knutson (2000) ran five simulations of the global climate for the period 1860 to 2000 using the same standard general circulation climate model. Each simulation had slightly different initial conditions, but was otherwise exactly the same. Some of the simulations replicated climate change similar to the pattern we have experienced. The point of this study was two fold. One is that as we don't know precisely what the "initial conditions" actually were when the various computer simulations of climate are run, the results might be largely due to internal variations, not external variables. The second is that as the natural processes are non-linear and non-ergodic, small variations may result in large changes. As a result, the simple deterministic computer simulations on which almost all climate change projections are based will have little to do with the real world.

Increased amounts of water vapour and Carbon Dioxide can result in less Ozone, as can a general cooling of the atmosphere. These impacts have to be understood in relation to the several distinct solar activity and lunisolar tidal periodicities over many time scales. It is misleading to think in terms of unique global temperature or pressure variations<sup>iv</sup>, to be characterised by a unique solar variability curve valid for the whole of the Earth's surface.

There are six well founded periods in solar variability: 1.3, 11, 22, 30-35, 88, and 179/205 years. Total solar variability varies over all of these to a varying extent. Ruzmaikin (2007) reported that observations, such as sunspot number records, indicate that the magnitude of solar variability increases from the solar rotation time scale (27 days) to

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longer time scales. In turn, the Earth's responses become more pronounced with the increase of time scale. A transition from shorter to longer time scales implies averaging over small-scale atmospheric disturbances. A transition of this type also results in the involvement of systems with more inertia than the atmosphere, namely the oceans. Nevertheless, in general terms, over the 80+ year Gleissberg cycle all types of solar activity increase (or decrease), and global warming (or global cooling) is the general result. There will be differential effects throughout the planet over the duration of the cycle. As a result of these exceedingly complex interaction effects, an overall impact of the longer term substantial increase in solar energy enveloping the Earth, and absorbed by it, is an increase in randomness in the climate system.

Two scientists at the Department of Civil and Environmental Engineering University of Melbourne, Dr Murray Peel and Professor Tom McMahon, have recently shown that randomness in the climate system has been on the rise since the 1950s (Peel and McMahon (2006)). The authors used the time series analysis technique, Empirical Mode Decomposition (EMD) to quantify the proportion of variation in the annual temperature and rainfall time series that resulted from fluctuations at different time scales. They applied EMD to annual data for 1,524 temperature and 2,814 rainfall stations from the Global Historical Climatology Network.

Peel and McMahon (2006) found that the proportion of variance due to inter-decadal fluctuations has been decreasing since the 1950s for rainfall and since the 1970s for temperature. They argue that this means the long term memory of the climate system is shortening, thus increasing the degree of randomness in the system.

A more general consequence of the foregoing is that the climate system can never reach an equilibrium state. This highlights a basic flaw in the value of the computer simulations of climate as a guide to what might happen in the world about us. All the computer models assume that the climate functions in an equilibrium state. But the real world is vastly more complex than the simulated world of the models and is never in an equilibrium state, more precisely, never anywhere near such a state.

Since the IPCC was established to examine climate change *which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere*, the IPCC has not considered the evidence reviewed above nor the broader field of research from which it is drawn.

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### *Climate consequences of Solar Cycle 24*

We are currently in period of solar minimum between the end of Solar Cycle 23 (SC23) and the beginning of Solar Cycle 24 (SC24), which is now expected to begin sometime between during 2008, most likely by the middle of the year.

The amplitude and shape of SC24 could be decisive about the extent to which global warming is the result of total solar variability or human activity. In view of the significance of SC24, in October 2006 NASA appointed a panel of world experts to advise the US Government about the development of SC24.<sup>v</sup> The Solar Cycle 24 Prediction Panel anticipates the solar minimum marking the onset of Cycle 24 will occur in March, 2008 ( $\pm 6$  months). If SC24 has a low amplitude and if the overall shape of the cycle is that of a flattened bell-shaped curve, it will most likely mean that SC24 will be the harbinger of three decades of global cooling to come and at least five years more drought in Australia.

Livingston (2004) found that the maximum of SC22 was statistically significantly stronger than the maximum of SC23. Penn and Livingston (2006) report that over the past eight years, throughout the life of SC23, the maximum sunspot magnetic fields have been decreasing by about 52 Gauss per year. They note that a continuation of the documented trends would mean that the number of sunspots in SC24 would be reduced by roughly half, and that there would be very few sunspots visible on the solar disk during SC25.

The Panel of experts appointed by NASA in October 2006 presented their interim report on April 25. The Panel was evenly divided between the scientists who considered that SC24 would have an unusually large or an unusually low amplitude. The Panel will report again before the end of this year.

The National Oceanic and Atmospheric Administration (NOAA) currently predict that the amplitude of Solar Cycle 24 will be relatively low. The NOAA predicts that SC24 will begin in June 2008, peak in August 2012 having maximum amplitude of 90.<sup>11</sup>

The differences between the Panel's two groups go to the heart of current theories about the inner most workings of the Sun, the processes by means of which the decaying latitudinal (i.e. toroidal) magnetic fields at the end of one solar cycle transform into the regenerated longitudinal (i.e. poloidal) magnetic fields of the emergent cycle.

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<sup>11</sup> [http://www.swpc.noaa.gov/ftpdirect/weekly/Predict\\_low.txt](http://www.swpc.noaa.gov/ftpdirect/weekly/Predict_low.txt)

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The principal proponent of the prediction that SC24 will have a large amplitude, (Dikpati, de Toma and Gilman (2006)), assumed that the process of regeneration is deterministic. They use sunspot area data as a deterministic source for the generation of the new longitudinal (poloidal) fields. Their prediction is based on computer simulation of the solar dynamo. However, Tobias et al (2006) drew attention to the highly speculative nature of this prediction. Amongst other things, they noted that the solar dynamo model used by Dikpati, de Toma and Gilman (2006) "relies on parametrization of many poorly understood effects" and that the model has no known predictive power. Furthermore, Dikpati, de Toma and Gillman (2006) have not yet released the code of their computer model for the scientific community to examine.

The key analysis that predicts that SC24 will have a low amplitude, (Choudhuri, Chatterjee and Jiang (2007), Jiang, Choudhuri and Wang (2007) and Jiang, Choudhuri and Wang (2007b) is based on evidence that the process that generates the regenerated longitudinal (poloidal) magnetic fields of the emergent cycle from the decaying latitudinal (i.e. toroidal) magnetic fields at the end of the old cycle is intrinsically random. They pointed to evidence that the build up of the new longitudinal (poloidal) fields during the declining phase of an ending cycle introduces randomness in the solar cycle processes. This randomness, they argued, means that longitudinal (poloidal) field generation (and therefore sunspot numbers) cannot be calculated deterministically from the past sunspot data.

In order to predict SC24, Choudhuri et al used actual measures of the strength of the longitudinal (poloidal) fields during the declining phase of an ending cycle in their computer simulation of the solar dynamo. The computer code of their model has been available to the scientific community for over two years, surviving intensive peer review scrutiny.

Choudhuri et al concluded that the SC24 will be the weakest in 100 years, about the same as Sunspot Cycle No. 14 (SC14).

Svalgaard, Cliver and Kamide (2005) predicted that SC24 will be significantly smaller and weaker than its predecessor and be just like SC14. Their prediction is based on an examination of the strength of the magnetic fields that congregate in the polar regions of the Sun a few years before the solar minimum of each solar cycle. They relate the strength of those fields to the observed sunspot numbers during the next solar maximum. The polar magnetic fields provide the 'seed' magnetic flux necessary to drive the sunspot activity during the next solar cycle. Svalgaard, Cliver and Kamide (2005) theorised that the solar polar fields will be weak during 2007-2008 and will

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remain weak. They have recently reported that the polar fields are the weakest ever observed.

Schatten (2005), using a similar analysis, reached the same conclusion. He found that the relevant coronal features do not show the characteristics of well-formed polar coronal holes associated with typical solar minima, but rather resemble stunted polar field levels. He noted that the Sun's polar fields have not strengthened comparably during 2000-2005, as in the previous few decades. He suggested that the dramatic field changes seen suggest the importance of field motions associated with meridional flows for the Sun's dynamo.<sup>vi</sup>

Clilverd et al (2006) used a previously validated model of solar variability that includes all known periodicities of solar activity. These include periods of 22, 53, 88, 106, 213 and 420 years that modulate the better known 11-year sunspot cycle. This is the only published model to include all solar periodicities. This model, which generally reproduces the periodicities in the sunspot data recorded since 1750, predicts that SC24 will be quieter than SC14. It also predicts that Sunspot Cycle Nos. 25 and 26 will be even more subdued. Furthermore, the model predicts that solar activity will return to more normal levels from Sunspot Cycle No. 27 onwards, that is by around the middle of the century.

Bonev, Penov and Sello (2004) examined long term trends in solar variability going back 4,500 years. They concluded that:

*The present epoch is at the onset of an upcoming local minimum in the long-term solar variability. There are some clues that the next minimum will be less deep than the Maunder minimum.*

Tobias et al (2006) cautioned against predictions of future sunspot cycle activity, arguing that solar activity is non-periodic not multi-periodic. Tobias et al (2006) conclude *The future of such a chaotic system is intrinsically unpredictable.*

A summary high level overview of the science can be found here:

<http://agenda.albanova.se/conferenceDisplay.py?confId=140>

There are good reasons to conclude that SC14, which began in 1901 and ended in 1912, was responsible for the Federation Drought, Australia's worst drought.

Australia's Bureau of Meteorology was one of the first government agencies in the world to publish reports linking solar activity and climate. In 1925 the Commonwealth

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Government's Bureau of Meteorology published a report linking the features of SC14 and Australia's climate at that time. Kidson (1925) considered that "The year 1914 was the culmination of what was in all probability the worst drought in Australian history" and attributed the drought to the weakness of SC14. In 1938 the Bureau published another report, Quayle (1938), which noted:

*A rough generalisation from the winter rainfall over northern Victoria would suggest that when the new solar cycle begins with a rapid rise to a definite peak then the heaviest rains are in the early years, but when the solar activity begins more gradually and takes four or more years to reach a low or moderate maximum, then comparatively poor seasons may be expected in the early part.*

This report updated Quayle (1925), the first scientific paper published in Australia about the relationship between the sunspot cycle and climate. Quayle's 'rough generalisation' has been corroborated by recent research.<sup>vii</sup>

The current drought, like all other major episodes of Australia's drought and flood, results from variations in total solar variability. This is largely a result of the significant impact of total solar activity on the El Niño Southern Oscillation (ENSO) atmospheric/oceanic system, an effect well documented in the literature, and other atmospheric/oceanic systems relevant to Australia's climate.

Decades of research have established that ENSO is the largest source of inter-annual variability operating in the Earth's climate system. Furthermore, it has been known for decades that the ENSO has a key role in the regulation of Australia's climate.

Nicholls (1992) established that ENSO is largely responsible for the regulation Australia's climate. He concluded:

*The El Niño/Southern Oscillation has a major effect on Australasian climate. The phenomenon amplifies the interannual variability of the climate and imposes temporal patterns, phase-locked to the annual cycle, on droughts and wide- spread, heavy rainfall episodes. The native vegetation and wildlife are clearly adapted to the pattern of climate fluctuations, especially rainfall variations, imposed by the El Niño/Southern Oscillation. This suggests that the El Niño/Southern Oscillation has been affecting the Australasian region for a very long time. The clear adaptation of the fauna and flora to the patterns of climate produced by the El Niño/Southern Oscillation indicates that paleoclimatic studies in the Australasian region may help determine when the phenomenon started to operate.*

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Other Australian scientists, (Franks (2002); Keim, Franks and Kuczera (2003); Keim and Franks (2004); and Verdon, Keim and Franks (2004), have found that ENSO, modulated by the Interdecadal Pacific Oscillation, is largely responsible for Australia's cycles of flood, drought and bushfire. Professor Franks has also shown how this knowledge can be used to better manage Australia's water resources and bush fire risks.

ENSO's role is most apparent in those areas of Australia that relate most directly to the Pacific Ocean. The Indian Ocean Dipole has a larger influence in Western Australia. The Southern Hemisphere Annual Mode has a larger role in those areas of Australia that relate most directly to the Southern Ocean. Both of these systems interact with ENSO variously amplifying or muting each others' effects. Variable solar activity has a key role in the behaviour of the three systems. Abram, Gagan et al (2007), a team at the Research School of Earth Sciences at the Australian National University, have recently shown that the Indian Ocean Dipole (IOD) has a more dramatic effect than ENSO on the climate of countries surrounding the Indian Ocean. Abram, Gagan et al (2007) reported that the IOD interacts with the ENSO so as to intensify climatic extremes of flood and drought. Hendon, Thompson and Wheeler (2006) reported that SAM tends to bring dry weather in winter to southeastern and southwestern Australia and wet weather and low temperatures in summer to most of central/eastern subtropical Australia and decreased rainfall in western Tasmania.

As Scafetta and West (2006b) reported, increased solar activity warms the oceans, increases the amount of water vapour and Carbon Dioxide in the atmosphere, and reduces the oceans' uptake of water vapour and Carbon Dioxide from the air. As a result, some of the atmospheric Carbon Dioxide that has been attributed to human activity has a solar origin. The resultant release of more water vapour and Carbon Dioxide into the atmosphere may have contributed to the warming that is already the direct result of increased solar output, variations in the Sun's electromagnetic and gravitational fields and interactions between the three. It is to be hoped that in its next series of publications the IPCC will quantify the proportion of greenhouse gases that have been produced by the Sun in this manner.

Planet is not warming as predicted by the IPCC. The UK's Climate Research Unit has updated its HadCRUT3v temperatures.<sup>12</sup> Global average anomalies for November and December 2007 are now present but are provisional for a few months in case late data arrives.

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<sup>12</sup> <http://www.cru.uea.ac.uk/cru/data/temperature/hadcrut3vgl.txt>

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November's global temperature anomaly of 0.258 was the lowest since October 2000 and December 2007 anomaly was lower than the anomaly of November. The annual global average for 2007 shows that 2007 was the coolest year since 2000. The annual average for the Southern Hemisphere in 2007 was the lowest since 1996. November and December temperatures were the coolest since 1992. The annual average for the Northern Hemisphere remained at the 2002-2006 level. A very warm start to the year offset the cooling late in the year.

### *The IPCC reliance on inappropriate time series analysis leads to erroneous conclusions*

(Koutsoyiannis (2000, 2002, 2003, 2005a, 2005b, 2005c)) and others have shown that time series of measures of geophysical and other complex systems are characterized by variations from the average that can be very large (catastrophic events) and simultaneously very long (persistence in time). In other words, hydrological and other geophysical time series show oscillations over many time scales. It seems that trends observed in relatively short time scales, such as 10 or 100 years, are but elements of oscillations that take place over longer time scales.

Time series simply record repeated measures of the same phenomena (such as rainfall, the height of tides, river flow, the amount of water in a dam, daily temperatures and pressures, the incidence of solar radiation, the number of sunspots) over time. Koutsoyiannis and others have shown that the time series hydrological, geophysical and climate phenomena reveal non-linear and non-stationary relationships within the phenomena observed over time.

These relationships are generically known as Hurst phenomena after the scientist who first brought the phenomenon to the attention of the scientific community. From the 1920s onwards, a hydrologist, Harold Hurst, was employed to examine the flow of the Nile.<sup>viii</sup> He noticed various interdependencies in the time series data of volume and flow measurements. He introduced the idea of long term persistence to refer time series in which there are hidden relationships between the recordings made at different times like those he found in the behaviour of the Nile, including those mentioned above. His time series spanned almost 850 years of recordings of volume and flow data of the Nile.

In the 1950s and 60s Benoit Mandelbrot re-examined the time series about river flows.<sup>ix</sup> In the 1960s, Mandelbrot and his colleague, James Wallis, wrote a series of papers dedicated to Harold Hurst. Drawing on the Old Testament, they used the term *Noah Effect* to refer to incidents of repeated rainfalls (sometimes leading to great floods) and the term *Joseph Effect* to refer to incidents where repeated years of great plenty are

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followed by repeated years of great famine. The time series of the Nile recordings contained both Noah and Joseph effects.

The challenge for the statistician is to establish whether effects such as the Joseph and Noah effects are part of the world or merely attributes of the data. If there are Noah and Joseph effects in the data, the statistician has to be able to establish if this means a real trend in the world. Alternatively the issue for the statistician to resolve might be has the data merely a certain structure that gives rise to the effects detected without there being an underlying trend in the world.

Mandelbrot found that the long range statistical dependencies that Hurst documented in his pioneering 1951 paper had a fractal structure. Mandelbrot proved that the fluctuations in water storage and runoff processes were self-similar over a wide range of time scales. There was no single characteristic scale. Hurst's finding is now recognized as the first example of fractal behaviour in empirical time series.

As Koutsoyiannis has shown in the abovementioned papers, because of the Hurst-type relationships between the variables at different times of measurement, it is invalid, therefore, to assume that the variables are normally distributed independent random variables

Nevertheless, Koutsoyiannis and others have shown that there is also an element of randomness in the time series of hydrological, geophysical and climate phenomena.

Time series analysis of such data should use methodologies that can detect non-linear and non-stationary relationships and identify reliably and validly the stochastic dynamics of the system. If such methodologies are not used, the time series analysis will not show the dramatic variations in the range and intensity of variability in phenomena characterised by intrinsic randomness and Hurst periodicity.

Huang et al (1998) have also highlighted the need to use analytic methodologies that reveal clearly any nonlinear relationships (that may also contain intrinsic trends) when analysing time series of natural phenomena. Huang et al (1998) showed that, necessarily, misleading conclusions will be drawn from the uncritical use of time series analytic techniques that assume relationships within the time series are linear, stationary and devoid of intrinsic trends.

Cohn and Lins (2005) brought attention to the non-linear, non-stationary nature of climate time series data. Cohn and Lins (2005) concluded:

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*These findings have implications for both science and public policy. For example, with respect to temperature data, there is overwhelming evidence that the planet has warmed during the past century. But could this warming be due to natural dynamics? Given what we know about the complexity, long-term persistence, and nonlinearity of the climate system, it seems the answer might be yes. Finally, that reported trends are real yet insignificant indicates a worrisome possibility: Natural climate excursions may be much larger than we imagine. So large, perhaps, that they render insignificant the changes, human-induced or otherwise, observed during the past century.*

(Koutsoyiannis (2000, 2002, 2003, 2005a, 2005b, 2005c)) and others have made clear, that the application of the Principle of Maximum Entropy<sup>13</sup> to real world variables, subject to the constraints of intrinsic randomness and the type of periodicity known as the Hurst phenomenon, is necessary. The Principle of Maximum Entropy is equivalent to the Principle of Stationary Action, an elementary principle of Physics. A practical and universal consequence of the Principle of Maximum Entropy, (and its equivalent, the Principle of Stationary Action), is that nature behaves in a manner that makes uncertainty as high as possible.

Classical statistics, applied to hydrology and climatology, describe only a portion of natural uncertainty, and underestimates seriously all relevant risks. Since the IPCC considers that all the forcing relationships, which in its view, make the climate, are simple linear relationships, it only looks for simple linear relationships in the time series data. All of the time series analysis carried out by the IPCC and the models used by the IPCC do not make any use at all of nonlinear methodologies for the analysis of time series. The IPCC has made extensive use of time series analysis. But it has ignored over 50 years of mathematical and statistical understanding of ways of extracting the maximum information from them. By ignoring all of this progress, the IPCC has come to erroneous conclusions about climate change.

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<sup>13</sup> The entropy of a set of mutually exclusive events is maximum when they are equi-probable. It is then equal to the natural logarithm of the number of events. The Principle is used to infer unknown probabilities from known information. According to the Principle, the probability distribution is assigned to the random variable that maximises the entropy of the set, subject to some conditions expressed as constraints, which incorporate the information already available in this variable's time series. The Principle was first formulated by Jaynes in 1957. His formulation was that we should have an exhaustive set of mutually exclusive hypothesis (this is the hypothesis space) that would predict, say, the next value in a time series. We should then assign a probability distribution to that set which maximises the entropy of the hypothesis set, subject to constraints that express properties we wish the distribution to have, but are not sufficient to determine it. By this procedure we get a probability distribution for the hypothesis space, not the probability of a particular hypothesis. It does not require the numerical values of any probabilities of particular hypotheses. It assigns those numerical values directly out of the information, as expressed by our choice of hypothesis space and constraints.

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However, the real relationships in the climate are nonlinear, non-( and dynamic. Time series data of climate change will necessarily therefore require techniques of nonlinear time series analysis to identify these dynamics, to formulate models of them and to evaluate the validity of the models.

A necessary condition for progress is that relationships between models and the real world be properly and continuously assessed. We know that the climate change is the order of the day on Planet Earth. Climate change has been abrupt and catastrophic in the past. The Little Ice Age, from which we have been emerging since the mid 19th Century, brought catastrophes around the world, causing famine and devastation throughout Europe. We are now in a period of global scarcity of oil. As a result, if there period of severe global cooling over the next several decades as indicated by the science of solar/climate relationships and predictions of the next three solar cycles, there would be a 30 year period of far greater hardship than our ancestors experienced during the last several cycles of the quieter Sun.

#### *Adaptive efficiency is the key*

In 1993 Douglass North, along with fellow economic historian, Robert W. Fogel, received the Noble Prize for Economics for pioneering work which resulted in the establishment of Institutional Economics, now a central school of modern economics. He introduced the idea of "adaptive efficiency" to describe how economies and societies work effectively, not at a moment in time, but through time. In his Noble Prize Lecture he reasoned that:<sup>14</sup>

*It is adaptive rather than allocative efficiency which is the key to long run growth. Successful political/economic systems have evolved flexible institutional structures that can survive the shocks and changes that are a part of successful evolution. But these systems have been a product of long gestation. We do not know how to create adaptive efficiency in the short run.*

Professor North explained that adaptive efficiency is a society's effectiveness in creating institutions that are productive, stable, fair, broadly accepted and flexible enough to respond to social, political, economic, and environmental crises. He explained that an adaptively efficient society will cope with the novelty and uncertainty of a non-ergodic world. It will do this by the maintenance of institutions which enable trial and error and

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<sup>14</sup> Prize Lecture to the memory of Alfred Nobel, December 9, 1993 on the website: [http://nobelprize.org/nobel\\_prizes/economics/laureates/1993/north-lecture.html](http://nobelprize.org/nobel_prizes/economics/laureates/1993/north-lecture.html)

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experimentation so that societal learning is effective, enabling the elimination of unsuccessful solutions and the retention of successful ones.

Douglass North (1999) considered that we live in a non-ergodic world. He explained that an ergodic phenomenon has an underlying structure so stable that theory that can be applied time after time, consistently, can be developed. In contrast, the world with which we are concerned is continually changing: it is continually novel. Inconsistency over time is a feature of a non-ergodic world. The dynamics of change of the processes important to us are non-ergodic. The processes do not repeat themselves precisely. North (1999) argued that although there may be some aspects of the world that may be ergodic, most of the significant phenomena are non-ergodic.

Douglass North stressed that our capacity to deal with uncertainty effectively is essential to our succeeding in a non-ergodic world. It is crucial, therefore, that the methodologies we use to understand the exceedingly complex phenomena measured in our time series, correctly inform us of the future uncertainty of the likely pattern of development indicated by the time series.

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**Attachment 1**

### Sir William Herschel and the Royal Society

In 1801 William Herschel (Herschell 1801a and 1801b) presented his ideas to the Royal Society about the relationship between sunspots and the price of wheat.

At the time William Herschel was 63. He had held the appointment of the King's Astronomer since 1782, was a Fellow of the Royal Society, which had awarded him the prestigious Copely Medal in 1781.

By 1801, William Herschel was acknowledged by all as Europe's most distinguished Astronomer.

He had built the largest telescope in Europe, discovered many new features of the Universe and documented much new detail about the Sun. He had shown that the solar system moves at high speed through the Universe. He had discovered the Sun's infrared radiation, showing that the Sun is a source of heat as well as light.

Examples of new astronomical phenomena he documented include the discovery of:

- Uranus and two of its moons;
- two satellites of Saturn and the period of rotation of Neptune's ring;
- more than 1,000 binary stars, each pair connected by gravitational force;
- between 2000 and 3000 nebulae and clusters of stars and delineation of the structure of the Milky Way;

He was a greatly admired scientist.

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In his 1776 book, *An Inquiry into the Nature and Causes of the Wealth of Nations*, Adam Smith had compiled details of English wheat prices over 562 years from 1202 to 1764.<sup>15</sup> Herschel had been studying sunspots and noticed that sometimes the Sun had more and sometimes less sunspots. He recorded what he saw. He reasoned that when there were more sunspots the Sun seemed to produce more 'light and heat' and when there were less, it appeared to produce less 'light and heat'. In 1801 he informed the Royal Society:

*Since light and heat are so essential to our well-being, it must certainly be right for us to look into the source from whence they are derived, in order to see whether some material advantage may not be drawn from a thorough acquaintance with the causes from which they originate.*

This was one of the driving motivations behind his detailed observation of the Sun which he communicated to the Royal Society in April and May of 1801.

His observations showed that sometimes the Sun had more spots than others, sometime it had no spots. He concluded that the Sun's output of 'light and heat' increased with the number of sunspots. He went over observational records since 1610 and identified five periods longer than two years in which no spots had been recorded. He reasoned that with no spots the Earth would receive less 'light and heat' and therefore be cooler.

Herschel faced the problem that there were no reliable measurements of atmospheric temperature and pressure for these years. After all, it was not until 1643 that Torricelli invented the first reliable barometer and 1714 that Fahrenheit invented the first Mercury thermometer.

Herschel reasoned that if the climate cooled in response to diminished 'light and heat' from the spotless Sun, the wheat harvest would be reduced and accordingly, the price of

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<sup>15</sup> Adam Smith had converted the prices over this period to standard price applicable at the time he wrote his book (1776). His major source of data was a *Chronicon Preciosum, or, an account of English money, the price of corn, and other commodities, for the last 600 years*: in a letter to a student in the University of Oxford, which included a compilation of the prices of many basic commodities compiled by William Fleetwood, the Bishop of Ely and St Asaph. Bishop Fleetwood invented index numbers. He wrote *Chronicon Preciosum* to answer the question "how much would £5 in 1440 buy in 1707?". The question arose because he would lose the fellowship of an Oxford college if he had outside income in excess of £5; the college statute was composed in 1440. Bishop Fleetwood showed how much bread, drink, meat, cloth and books could be purchased at the earlier and later dates. He tabulated the changing prices of many commodities and noted that most of the prices grew at the same rate. He concluded that £5 in the fifteenth century would be worth £28 or £30 at the beginning of the eighteenth. The Nineteenth Century economist, Professor Francis Edgeworth, once remarked that the *Chronicon Preciosum* was "the oldest and one of the best treatises on index-numbers." Adam Smith used prices from the *Audit Books of Eton College*, quoted by Charles Smith, *Three Tracts on the Corn Trade* (London, 1766), to supplement Bishop Fleetwood's data so that the time series continued up to 1764.

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wheat would rise. He further reasoned that the effect of variable solar output on vegetation would be similar to the effect of the Sun and the Moon on the tides. That is, that in some parts of the world the tides are very high and very low and that the tidal phenomena vary around the world over time and in relation to latitude and longitude. He pointed out that even though there were these great variations, the tidal phenomena are universally the result of a single principle, the variable gravitational force of the Sun and the Moon, as Newton had shown.

Herschel applied his test to the five lean periods by tabulating the price of wheat for these periods. He used the 562 year time series of wheat prices published 25 years earlier by Adam Smith (also a Fellow of the Royal Society).

Herschel found, and reported to the Royal Society that, roughly speaking, the price of wheat in England was highest when sunspots were absent. He summed up his argument in this way:

*The result of this review of the foregoing five periods is, that, from the price of wheat, it seems probable that some temporary scarcity or defect of vegetation has generally taken place, when the Sun has been without those appearances which we surmise to be the symptoms of a copious emission of light and heat.*

His presentation of his analysis is full of qualifications about:

- the deficiencies in the available data about the sunspot record;
- the condition of the climate during the period under review; and
- using data about the price of wheat in England for a specific period to infer general conclusions about a relationship between variable solar output and climate for the world.

He also addresses the concern that 'the general fertility of the earth' will depend on many other variables that are probably unrelated to 'a certain quantity of sun-beams'.

In relation to this, he noted as follows:

*To this I only suggest, by way of answers, that those very circumstances of proper alternatives of rain, dry weather, winds, or whatever else may contribute to favour vegetation in this climate, may possibly depend on a certain quantity of sun-beams, transmitted to us at proper times.*

In her biography of her Grandfather, Sir William Herschel, Lady Constance Lubbock records that her Grandfather was subject to much criticism and some ridicule. Generally

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speaking, the Royal Society reacted with almost total derision, even though Herschel was one of its most distinguished members. Things got so bad that he had to cancel a series of public lectures planned for later in 1801; such was the public derision of his theory.<sup>16</sup>

In October 1802 Henry Brougham, then aged 25, launched the *Edinburgh Review*. It was to become one of the most influential British magazines of the 19th century. He had already been elected a Fellow of the Royal Society; he was a distinguished barrister; an up and coming Whig, i.e. free market politician and prolific man of letters. Henry Brougham quickly became known as the foremost contributor to the *Edinburgh Review*. He wrote articles on everything: science, politics, colonial policy, literature, poetry, surgery, mathematics and the fine arts.

In the second issue of the *Edinburgh Review* in January 1803, Brougham (Brougham 1803) published a review of several papers that William Herschel had presented to the Royal Society in the previous few years and published in the Royal Society's *Transactions*. It is a highly personal attack on William Herschel, mocking him for the great variety of Ancient Greek names he gave the celestial bodies, including the new term "asteroid". The article is an unrelenting ridicule of William Herschel and many of the discoveries and insights he reported to the Royal Society.

Brougham saves his most vindictive comment about Herschel's theory of a relationship between variable solar activity and the price of wheat. Henry Brougham wrote:

*To the speculations of the Doctor on the nature of the Sun, contained in the last volume [of the Transactions of the Royal Society], we have many similar objections but they are eclipsed by the grand absurdity which he has committed in his hasty and erroneous theory concerning the influence of the solar spots on the price of grain.*

Sir Joseph Banks, the President of the Royal Society, implored William Herschel to ignore the 'darts' of Henry Brougham, assuring William that "...nothing can affect and overturn truths and discoveries founded on experience and observation."

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<sup>16</sup> The Prince Regent knighted William Herschel in 1816. His sister Caroline, who worked very closely with him throughout his career, compiled a very detailed journal of almost everything about her older brother. Lady Constance Lubbock, the youngest of the twelve children of Sir William's only son, Sir John Herschel (who was to become even more famous than his father) wrote a comprehensive biography of Sir William Herschel, published by Cambridge University in 1933. Lubbock, Constance A., *The Herschel Chronicle: The life-story of William Herschel and his sister Caroline Herschel*. Cambridge University Press 1933.

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Henry Brougham would rise far in politics becoming Lord Chancellor and Baron Brougham in 1830, receiving a second peerage 30 years later.

In 2004 *Solar Physics* published a paper by Lev Pustilnik, an astrophysicist at Tel Aviv University, and Gregory Yom Din, an agricultural economist at Haifa University, also in Israel (Pustilnik and Yom Din 2004). The paper reported their analysis of records of the price of wheat in England from 1259 to 1702 in relation to the established sunspot record.

They found that Herschel was right: the cost of wheat was high in medieval England during periods when there were hardly any sunspots, and low during solar maxima.

Their source of data on prices was the 50-year research of Professor Thorold Rogers (Rogers 1887) who collected data on England's agricultural prices for the 450-year period (1259–1702). Roger's data were drawn principally from the account books of numerous English monasteries, and in part from those of landowners.

The following year *Solar Physics* published a second paper by the two authors extending their analysis to wheat prices in the US during the 20th century (Pustilnik and Yom Din 2005). The authors recorded their surprise, finding a relationship between numbers of sunspots and the price of wheat, just like Sir William hypothesised. The authors did not expect to see a sunspot connection due to modern technologies that make crops more robust in unfavourable weather; globalised markets; and the massive economic disruption that occurred during the two world wars. They reasoned that these factors should have cancelled out any variation in the data attributable to a sunspot effect.

They surmise that the effect persists because 70% of US durum wheat grows in one part of North Dakota, where localised weather conditions could have a dramatic impact on total production.

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### Attachment 2

#### Solar variability and Earth climate dynamics: additional detail

Rottman (2006) explained that the output from solar activity is the dominant energy input into the Earth's climate system. The atmosphere absorbs about 20% of solar radiation (globally averaged), establishing its structure, composition and temperature. About 30% is scattered and reflected back into space. The remaining 50% is absorbed at the surface, warming the land and the oceans and sustaining life. Changes in solar output have direct and indirect effects on the Earth's climate system. According to Rottman (2006), implications of a solar role in the climate system are evident in most climate records.

#### *The variable output of electromagnetic radiation*

The Sun's variable electromagnetic radiation heats and cools the Earth during the 11 year solar cycle. The extent that it does so depends on several features of the cycle: its duration, amplitude and the rate at which it rises and falls. It also depends on the relative proportions of short (Ultra-Violet and X-rays) and long (light and infrared) wave radiation produced by the Sun. This proportion varies with the solar cycle as does the absolute amount of radiation.

About 60% of the total change in irradiance of the Sun between solar maximum and minimum is produced in the Ultra-Violet part of the spectrum. However, only about 8% of the Sun's electromagnetic radiation is emitted at these wavelengths.

Short wavelength radiation ionises the upper atmosphere and heats the middle atmosphere. As a result, atmospheric temperature varies in a nonlinear manner with the amount and type of solar radiation. During the maximum phase of the solar cycle, the Sun produces proportionately more Ultra-Violet radiation than visible and infrared light. It also ejects proportionately more matter. Furthermore, over the last 130 years the Sun's production of Ultra-Violet radiation and matter has increased at a proportionally greater rate than visible and infrared light.

#### *The variable output of matter*

The Sun ejects enormous quantities of matter continuously in the form of the solar wind or periodically as either a mix of high energy protons and electrons (Coronal Mass Ejections, (CMEs)) or as mostly high energy protons (Solar Proton Events (SPEs)).

The Earth's atmosphere is more sensitive, and more reactive, to the CMEs and SPEs than to the Sun's short wavelength radiation, to which it is, in any case, highly reactive. The effect of CMEs and SPEs is to reduce the amount of Ozone, cooling the middle



































































