Assessing Climate Change

Temperatures, Solar Radiation, and Heat Balance

Donald Rapp

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Dr Donald Rapp
Independent Contractor
South Pasadena
California
USA

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Preface

THE GLOBAL-WARMING DEBATE

Global-warming alarmists believe that human production of greenhouse gases, particularly carbon dioxide, with its concomitant water vapor feedback mechanism, has begun to add to the natural greenhouse effect, thereby raising global temperatures inordinately during the 20th century, with predictions of further increases in the 21st century that could be catastrophic.

Dr. James E. Hansen, perhaps the most respected spokesman for the alarmists, said: "Ignoring the climate problem at this time, for even another decade, would serve to lock in future catastrophic climatic change and impacts that will unfold during the remainder of this century and beyond." The Earth "is close to dangerous climate change, to tipping points of the system with the potential for irreversible deleterious effects ... The planet is on the verge of dramatic climate change." We "are forced to find a way to limit atmospheric CO_2 more stringently than has generally been assumed ... We cannot shrink from our moral responsibilities ... to preserve the planet for future generations."

Al Gore's film *An Inconvenient Truth* has carried the message to many millions of people. This has spawned a growing world movement that is seeking controls on greenhouse gas emissions. Because such controls would have serious economic consequences, and furthermore, attempts to apply controls have been unbalanced relative to developed countries vs. developing countries, there has been strong resistance to such moves by naysayers.

Naysayers have maintained blogs and circulated reports, but generally have not penetrated the scientific literature that is dominated by alarmist publications. While the alarmists provide the impression of scientific integrity through peer-reviewed publications, the naysayers often lack the credentials of alarmists. But the important thing is data, not credentials.

Both sides have argued like trial lawyers with a case to be made, by craftily selecting bits and pieces of data to support their preconceived viewpoints. Fact, supposition, speculation, and pseudo-science have been mixed together in a brew that is confusing and difficult to resolve. One thing the world does not need is another high-level book arguing with assurance on one side of the question or the other, with little actual data content, manipulated to achieve an apparent conclusion based on specious arguments and cunningly selected references.

In this book, I have investigated a large body of technical data relevant to global climate change, approaching each element with necessary (but hopefully neutral) scientific skepticism. As Einstein said: "The goal is to be as simple as possible, but not simpler." Thus, by necessity, this book is quite technical, but hopefully still quite readable.

The essential questions are:

(1) How well has the world monitored near-surface temperatures of the 30% land and 70% ocean areas on Earth during the past 100 years or more, and how well can we characterize the changes in climate over that time span?
(2) What is the utility and significance of a single global average temperature?
(3) How has the Earth's climate varied over the past ice ages, the Holocene, the last millennium, and the past century, and what can we infer about "natural" variability of the climate prior to industrialization by humankind?
(4) How reliable are proxies for historical temperatures? What do we really know about past temperature variations? Is the *hockey stick* version of millennium temperatures credible, in which temperatures were flat for two thousand years prior to a sudden rise in the 20th century?
(5) How does the current global-warming trend compare with past fluctuations in the Earth's climate, and what is the likelihood that the warming trend we are experiencing now is primarily just another in a series of natural climate fluctuations as opposed to a direct result of human production of greenhouse gases?
(6) How credible are the global climate models that claim that greenhouse gases produced most of the temperature rise of the 20th century, and forecast much greater impacts in the 21st century?
(7) How good were the "good old days?" Was the climate of the Little Ice Age ideal, should we abhor warming from that baseline, and do we want to return to the climate of the 19th century?
(8) How will limits on fossil energy supplies constrain future CO_2 production and climate change, even if the climate models are accurate?
(9) How can the world provide itself with energy needed for a burgeoning population that will demand more and more energy in the future, considering the finite limits on fossil fuel resources?

According to Beckman and Mahoney (1998):

> "The vested interests on both sides of the argument between the 'greenhouse' party and the 'solar warming' party are obvious. Scientifically, the meteorologists,

> climatologists, and atmospheric physicists, who were responsible for 'discovering' the human contribution to the terrestrial greenhouse effect, have been the most consistent champions of its importance, while the solar physics community, and especially those interested in solar–terrestrial relations, have increasingly stressed the possible importance of the long-term variations of the solar constant as the chief cause of climate change. Both communities tend to take the change for granted, and to neglect any purely statistical or chaotic effects which could lead to excursions of the Earth's surface temperature during periods of a couple of decades, without requiring a secular change either in the solar constant or in atmospheric transparency. In addition, the debate is conditioned by more powerful vested interest groups. The oil industry in all its guises would obviously like to believe, and would like the public to believe, that greenhouse warming has been greatly exaggerated, and exploits any genuine scientific differences to undermine the credibility of the climatologists."

Unfortunately, the majority of global-warming alarmists have weakened their cases by building them around models and analyses of dubious veracity, and in the case of the infamous *hockey stick* temperature profile, mathematically incorrect manipulations of past temperature data from proxies. From this, they have concluded improperly that the late 20th century is far warmer than any time in the distant past, and made other elaborate claims regarding recent warming trends and dire predictions for the near future that are unsupportable by the evidence. Furthermore, the network for monitoring the Earth's temperatures is inadequate to precisely characterize the trends in climate for the past ~100 years, and the utility of a single global average temperature is limited.

Projections for the 21st century are typically far out of line with realistic expectations. The credence attributed to global climate models belies their inherent fragility. This has provided the naysayers with plenty of ammunition with which to debunk these exaggerated claims. On the other hand, most of the naysayers made up their minds *a priori* that global warming in the 21st century due to CO_2 emissions is not a potential problem, and their arguments are often vague and hardly convincing.

A major problem in discussing climate change is that we lack a time period that we can objectively define as a base for comparison. As Anon. (N) emphasized, temperatures near the end of the 20th century were generally higher than those of the preceding four centuries. Taken at face value, this seems to imply that the preceding temperatures were normal, while the relatively higher temperatures at the end of the 20th century are comparatively abnormal. However, the preceding four centuries extended across the *Little Ice Age*, and therefore one might state the proposition differently: Temperatures during the preceding four centuries were colder than they were at the end of the 20th century. Stated this way, the abnormality is attributed to the *Little Ice Age*. Perhaps the most accurate statement is that there is no normal climate, and the climate of the Earth has always varied widely, and continues to do so to this day. As Balling, Vose, and Weber (1998) said:

"... it is entirely possible that the warming in the record of the past century has been caused by an unusually cool period 100 years ago as opposed to an unusually warm period in recent decades."

> Current warming trends seem more insidious when compared with a norm taken as the *Little Ice Age*.

By carefully sifting through the evidence, we find that there are no ironclad answers to major questions on global climate change. Our temperature data for the past century are fragmentary and sparse, both spatially and temporally. Urban heat islands and land clearing have affected measured temperatures. Past variations in solar irradiance can only be estimated with speculations. Proxies used to estimate the temperature history of the Earth over the past millennium are noisy and inconsistent, leaving us with uncertain indications of the past. Climate models do not deal realistically with water vapor, aerosols, and clouds, resulting in wide variations from model to model.

> The thesis of this book is that our data and models are presently inadequate to reach credible conclusions regarding how much global warming is likely to take place in the 21st century. We have emerged from the *Little Ice Age* in the latter half of the 19th century and the Earth has warmed, but the connection to greenhouse gases remains very unclear. The roles of urban heating and changes in ocean circulation appear to have been underestimated by modelers.

Scientists (and the public) abhor a vacuum. They can't seem to shrug their shoulders and admit that we just don't know the answers to important questions. They introduce explanations, however speculative. Thus, we are besieged with models purporting to describe the past millennium's history of the Earth's climate, and making firm predictions about the future, none of which stand up to detailed review. The alarmist group that controls the paleo-climatological literature has a political agenda to promote public concern about greenhouse gases, and in many cases, they have lost objectivity. The opposition, whom I call naysayers, tend to be less well informed, often quite shallow, and equally one-sided. We have ended up with two opposing camps: the alarmists and the naysayers, each 100% convinced they are right, and each firmly for or against a global-warming catastrophe, each seemingly more concerned with furthering their agendas than with discovering truth. The world will face a crisis sometime around 2030. But that crisis will not be calamitous global warming. The crisis will be that with oil, gas, and coal production going at full bore, the world will not able to supply the energy that is demanded by a growing world population intent on using energy at higher rates. This could lead to significantly higher energy costs, resulting in worldwide economic recession or depression. However, on the positive side, it will provide great incentive to develop renewable energy that will then become

more competitive. Whether renewable energy can be developed and expanded rapidly enough to stave off economic collapse remains to be seen.

ORGANIZATION OF THIS BOOK

This book is based on a logical flow as shown below.

How climate has varied in the past and present

Proxies for estimating historical temperatures

⇓

Description of ice ages and sudden climate change

⇓

Fluctuations in the relatively benign Holocene (last ~10,000 years)

⇓

Temperature fluctuations during the past millennium (the *Medieval Warm Period* and the *Little Ice Age*)

⇓

The *hockey stick* controversy regarding temperatures in the last millennium

⇓

Temperature measurements in the last century; spatial and time dependence of 20th-century warming.

Factors that can cause the Earth's climate to change

Models to roughly estimate past variability of solar irradiance

⇓

Recent measurements of solar irradiance

⇓

Uncertainties in long-term stability of the Sun

⇓

Heat flows in the Earth's land–ocean–atmosphere system; the greenhouse effect

⇓

Role of ocean currents in heat transport

⇓

Global climate models, their predictions of heating due to greenhouse gases, and their limitations.

Carbon dioxide concentration in the atmosphere

Estimates of historical variability from proxies

⇓

Measurements in the 20th century

⇓

Fluctuations in the relatively benign Holocene (last ~10,000 years)

⇓

Predictions of future levels and consequent temperature increases

⇓

Likely constraints imposed by limitations of available fossil fuels.

Impacts of future global warming

Alarmist–Naysayer orthogonality

⇓

Most significant concern: future sea level rise.

Public policy: Kyoto Protocol

Developed vs. developing countries

⇓

Free rein to China to generate greenhouse gases

⇓

Punishment of countries that have done the most to reduce emissions in the past

⇓

Fallacies of the Stern Report.

Summary

There is a good deal more that we don't understand about climate variability than we do understand

⇓

The warming of the 20th century represents emergence from the *Little Ice Age*.

⇓

The role of greenhouse gases in this warming remains uncertain

⇓

We need better data and better models; there are too many speculations that have hardened into beliefs.

Scientists have studied past climates using *proxies*. Proxies are residual data from processes that occurred in the past, when the processes were dependent on local temperatures at the times they took place, and the evidence is preserved in the present in an accessible form. Chapter 1 provides a description of various proxies and their limitations. Chapter 2 examines what we have learned from proxies about major climate changes that have occurred in the past, starting with recent ice ages, followed by the Holocene (the past ~10,000 years), and then the last millennium. A rather blurry picture emerges of wild and rapid climate changes in the past, followed by a relatively benign Holocene that included some smaller fluctuations. A detailed study of proxy evidence for climate fluctuations in the last millennium has led to a controversy. While some climatologists claim that temperature changes in the last millennium were small prior to the 20th century, leading to a *hockey stick* graph of temperature vs. time with an unprecedented sudden rise in the 20th century, there is considerable evidence that temperatures varied significantly during the past millennium, and the temperature rise during the 20th century represented emergence from the so-called *Little Ice Age*. This controversy is examined in considerable detail.

Chapter 3 analyzes the measurements of Earth surface temperature that were made in the past century and discusses the limitations of the measurement network. Temperature data are reviewed in considerable detail. The primary trend during the 20th century has been upward from the base of the *Little Ice Age*, but this temperature rise has not been uniform, either geographically or in time. The limitations of attempting to describe the Earth with a single global average temperature are emphasized.

Chapter 4 provides an in-depth review of solar irradiance: historical observations, recent measurements, theories and models, and use of proxies to estimate past irradiance. There remains considerable uncertainty as to how solar irradiance varies over time periods of centuries. It seems likely that these uncertainties tie closely to uncertainties in historical temperatures during the past millennium, since solar variations are a likely source of temperature change in the absence of large-scale anthropogenic influence.

In Chapter 5, the greenhouse effect is discussed in the context of the Earth's heat balance and the heat flows that take place between land, ocean, and atmosphere. The growing importance of urban heat islands is emphasized. The role of the oceans is certainly important. This chapter ends with a description of global climate models and their predictions of the role of greenhouse gases in producing future global temperature increases.

Chapter 6 describes what we know about CO_2 concentrations in the atmosphere, past and present. Projections of future growth in CO_2 concentration are reviewed and compared with likely scenarios based on limited future availability of fossil fuels. Many climatologists have projected very steep increases in CO_2 concentration for the 21st century, which global climate models claim would lead to significant temperature increases. However, it is shown that there probably isn't enough fossil fuel to produce these putative increases in CO_2, and the accuracy of global climate models in predicting temperature rise due to greenhouse gases remains uncertain.

Chapter 7 deals with the potential impacts of future global warming by contrasting the views of alarmists and naysayers. While alarmists have exaggerated many risks, a significant concern is the potential future rise in sea level.

Chapter 8 deals with the Kyoto Protocol. It is not an equitable plan, and it suffers from a number of faults. Developing nations are given *carte blanche* while developed nations are punished for past improvements. China, soon to be the world's leading generator of greenhouse gases is absolved. Credits to allow greenhouse gas generation are a step in the wrong direction. The requirements imposed on developed nations are unattainable.

Chapter 9 provides a summary and conclusions. The Earth's climate is very complex. There is more that we don't know than we do know about climate change. Past temperatures, long-term variation of solar irradiance, variations in ocean circulation, heat exchange between the Earth and the atmosphere all remain (like most analyses of climate) speculative, conjectural, and unproven.

The Appendix reviews the widely viewed Al Gore film *An Inconvenient Truth*, for which he received a Nobel Prize. This glossy, glib presentation has little actual content.

Figures

Tables

* Unnumbered table.

Acronyms and abbreviations

ABL	Atmospheric Boundary Layer
ACRIM	Active Cavity Radiometer Irradiance Monitor
AE	Auroral Electrojet (index)
AIT	*An Inconvenient Truth*
AOGCM	Atmosphere–Ocean General Circulation Model
BP	Before the Present
CET	Central England Temperature
CFI	Comprehensive Flare Index
CFR	Climate Field Reconstruction
CME	Coronal Mass Ejection
CNES	Centre National d'Etudes Spatiales
CO_2e	Equivalent CO_2 concentration to produce the equivalent effect of all greenhouse gases.
CQSM	Constant Quiet Sun Model
DIC	Dissolved Inorganic Carbon
DTR	Diurnal Temperature Range
EA	East Antarctica
EAIS	East Antarctica Ice Sheet
ELA	Equilibrium-Line Altitude
ENSO	El Niño/Southern Oscillation
EOS	Earth Observing System
ERB	Earth Radiation Budget
ERBS/ERBE	Earth Radiation Budget Satellite/Earth Radiation Budget Experiment
EOF	Empirical Orthogonal Function
EPICA	European Project for Ice Coring in Antarctica
GCM	Global Climate Model
GDP	Gross Domestic Product

GHG	GreenHouse Gas
GIS	Greenland Ice Sheet
GISS	Goddard Institute for Space Studies (NASA)
GMST	Global Mean Surface Temperature
GRACE	Gravity Recovery And Climate Experiment
GSL	Global Sea Level
GSN	Group Sunspot Number
GST	Ground Surface Temperature
HadCM3	Hadley Climate Model 3
HFC	HydroFluoroCarbon
IMF	Interplanetary Magnetic Field
IPCC	Inter-government Panel on Climate Change
IR	InfraRed
LFO	Low Frequency Oscillation
LGM	Last Glacial Maximum
LIA	Little Ice Age
LULC	Land Use/Land Clearing
M&M	McIntyre and McKitrick
MBH	Mann, Bradley, and Hughes
MDI	Michelson Doppler Imager
MIROC3.2	Model for Interdisciplinary Research on Climate
MM	Maunder Minimum
MOC	Meridional Overturning Circulation (Atlantic)
MSU	Microwave Sounding Unit
MWP	Medieval Warm Period
NADW	North Atlantic Deep Water
NAO	North Atlantic Oscillation
NCEP–NCAR	National Centers for Environmental Protection/National Center for Atmospheric Research
NDVI	Normalized Difference Vegetation Index
NH	Northern Hemisphere
NOAA	National Oceanic and Atmospheric Administration
OHCA	Ocean Heat Content Anomaly
OPEC	Organization of Petroleum Exporting Countries
PC	Principal Component; Politically Correct
PCA	Principal Component Analysis
PFC	PerFluorohydroCarbon
ppmv	parts per million by volume
RE	Radiative Effectiveness
RSL	Relative Sea Level
SD	Standard Deviation
SEAS	NOAA's XBT program
SH	Southern Hemisphere
SMAX	Sunspot MAXimum
SMIN	Sunspot MINimum

SMM	Solar Maximum Mission
SN	Sunspot Number
SO	Southern Oscillation
SOHO	SOlar Heliospheric Observer
SOI	Southern Oscillation Index
SORCE	SOlar Radiation and Climate Experiment
SST	Sea Surface Temperature
TAV	Tropical Atlantic Variability
TIM	Total Irradiance Monitor
TMN	Temperature Measurement Network
TOA	Top Of Atmosphere
TOPEX-Poseidon	Ocean Topography Experiment
TSI	Total Solar Irradiance
UAH LT	University of Alabama in Huntsville Lower Troposphere
UARS	Upper Atmosphere Research Satellite
UHI	Urban Heat Island
UNFCCC	U.N. Framework Convention on Climate Change
U/P	Umbra/Penumbra
USHCN	U.S. Historical Climate Network
UT	Upper Troposphere
VEI	Volcano Explosivity Index
VIRGO	Variability of solar IRradiance and Gravity Oscillations
WA	West Antarctica
WAIS	West Antarctica Ice Sheet
XBT	eXpendable BathyThermographs
YBP	years before the present