Article

Global Warming: Scientific Basis and Christian Responses

Thomas Ackerman

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From the Book of Job, Chapter 38:1, 33–37:

1 Then the LORD answered Job out of the storm. He said:
33 Do you know the laws of the heavens? Can you set up God's dominion over the earth?
34 Can you raise your voice to the clouds and cover yourself with a flood of water?
35 Do you send the lightning bolts on their way? Do they report to you, "Here we are?"
36 Who endowed the heart with wisdom or gave understanding to the mind?
37 Who has the wisdom to count the clouds? Who can tip over the water jars of the heavens when the dust becomes hard and the clods of earth stick together?

The era of procrastination, of half measures, of soothing and baffling expedients, of delays, is coming to its close. In its place we are entering a period of consequences —Winston Churchill, 1936.

Global warming has become a divisive force in American politics and in American life, a division which has extended to the evangelical Christian community.

In the last twenty years, the science of greenhouse gases and global warming has moved from the often stuffy pages of academic journals to the front pages of newspapers and even to the movie theater. It has become the subject of international reports,[1] international conferences and protocols,[2] and Congressional hearings. It has become a divisive force in American politics and in American life, a division which has extended to the evangelical Christian community. The Evangelical Climate Initiative, representing one segment of the evangelical community has produced a statement that proclaims the reality of global warming and its serious consequences and the urgent need for evangelicals to respond.[3] In rebuttal, the Interfaith Stewardship Alliance claims that global warming, if happening at all, is natural and benign, and evangelicals should actively oppose any measures to mitigate it.[4] The result is that many citizens of the United States, including Christians, find themselves conflicted about the facts of global warming and the role of humankind in climate change.

In this article, it is my goal to address two broad themes. The first is the scientific basis of climate change, which I address by answering a set of science questions:

1. Is climate changing and, if so, on what time scale?
2. Do we understand the role of greenhouse gases in climate and climate change?
3. What is the impact of human activities on greenhouse gas concentrations compared to those of natural processes? Can these activities impact global climate?
4. Can we predict climate change during this century? What confidence should we have in such predictions?

The second theme is how evangelical Christians are responding to this issue. I attempt to categorize these responses under several headings. I end with my own personal response.

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Is climate changing and, if so, on what time scale?

Earth scientists (a term which refers collectively to scientists interested in atmospheric sciences, oceanography, polar processes, geosciences, and Earth climate history) deal with a very broad range of time scales. This range separates into three categories: weather (one to fourteen days), climate (year to centuries), and geological time (thousands of years to millennia and beyond).[5] From a mathematical perspective, weather prediction is an initial condition problem. We specify a mathematical model of atmospheric fluid dynamics and associated physics, initialize that model with the current state of the atmosphere, and then integrate forward in time to predict the future state. Such predictive efforts, while very accurate in the time frame of a few days, decline in accuracy with time, generally failing to demonstrate any skill after about ten days. While we have extended the limit of useful prediction in the last few decades, there are real temporal limits to predictability due to our incomplete understanding of the weather system and our inability to specify completely and accurately the initial state of the atmosphere.

Climate, on the other hand, is a boundary condition problem. We take the same mathematical model (actually, one that is more complex because it must include a coupled ocean model and sea ice model) and now integrate it forward in time constrained by energy fluxes at the boundaries, primarily the top of the atmosphere. These include the changes in the energy output of the sun, orbital parameters for the earth which affect the amount of solar energy intercepted by the earth, and atmospheric composition. It may seem odd to include atmospheric composition as a "boundary" condition, but we do so because, except for water vapor, the important constituents of the atmosphere are largely unaffected by climate processes on the decadal to century time scale. Hence, they are specified externally rather than calculated within the model. Determining the accuracy of climate prediction is difficult and will be discussed later.

The important distinction between weather and climate prediction is that, on the climate scale, we make no claim to predict actual events. We are instead predicting the statistical envelope of weather events, which we aggregate to call climate. This point may be somewhat clearer if we consider the annual Fourth of July picnic. If we are asked in January to predict the weather on July 4, any reputable meteorologist will answer that it is impossible to do so. If we are asked to predict the climate on July 4, we can do so easily by accessing the record of observed weather and providing a statistical description of the mean temperature, likely range of temperatures and probability of rainfall. The fact that we cannot predict the exact weather on next July 4 has no bearing on our ability to predict the climate on July 4.

Changes on geological time scales are generally connected to changes in the boundary conditions of climate. These include changes in the solar energy output, long period cycles in the earth's orbital parameters, continental drift, and atmospheric composition. Our knowledge of changes on geological time scales is a mixture of what we infer from geological records and fairly simple models of large scale physics and chemistry. While we have considerable understanding of geological history, our predictive capability is very limited.

We are concerned here with change on climate time scales. The simplest variable that we can examine is the surface air temperature, since it has been measured in many places for decades to centuries. Reliable measurements on a global scale are available from about the mid-1800s and have been used to reconstruct temperature (Figure 1, p. 252). Surface air temperatures were generally unchanged from 1850 to 1900, increased somewhat from 1900 to 1940, decreased and flattened from 1940 to 1975, and then experienced a rapid rise from 1975 to 2005. Although the total change is small (less than 1 °C), this must be compared with the change in global temperature between the last glacial 20,000 years ago and the current interglacial, which is between 5 and 8 °C, or about 1 °C per 2,500 to 4,000 years. Thus a 1 °C change in one hundred years represents a significant fraction of that change and a very rapid acceleration of the rate of change.

There are many other indicators of a warming climate; we list some here without further discussion. References and further detail are available in the International Panel on Climate Change (IPCC) reports.[6] These indicators include:

- Warming of the atmosphere over the last fifty years consistent with the changes in surface temperature
- Warming of the ocean
- Decrease in late summer arctic sea ice extent by 25% since 1900, mostly since 1950, and a corresponding decrease in sea ice thickness
- Retreat of almost every glacier in the world
- Lengthening of the growing season in the United States by three to five days in the last century
- Shifts in the poleward migration of birds and insects in the northern hemisphere toward earlier dates in the spring

The evidence of the last century, particularly the last quarter century, clearly shows a warming climate. In addition, the warming rate has accelerated over the last few decades (Figure 1).

A related question is whether this change is part of some longer term natural cycle. Although we do not have enough globally-distributed thermometer records that extend back in time, climate proxies—tree rings, coral growth, or lake sediment cores, for example—can tell

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us about relatively warm and relatively cool periods. Figure 2 (p. 253) depicts a 1200-year record of temperature anomalies (differences from the mean temperature) based on these climate proxies. The diagram tells us one fact immediately. There is no simple cycle of warming and cooling recorded over the last 1200 years. The scientists who constructed this diagram carried out a statistical analysis of the records to determine whether the peaks and valleys could have occurred by random chance. The highest solid line represents a 99% confidence level that any events above this line did not occur by random chance. As we can see, the warming of the last fifty years is the greatest in the entire record, and there is a vanishing probability that this occurred by chance.

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Do we understand the role of greenhouse gases in climate and climate change?

The so-called greenhouse effect is an indispensable component of the earth's climate. Solar radiation passes through our atmosphere, largely unattenuated by absorption, although about 30% of the incident radiation is reflected back to space by the atmosphere and the earth's surface. Outside of the air molecules themselves, the largest contributors to reflection are clouds and snow and ice surfaces. The earth's system balances this absorbed solar radiation by radiating heat to space at thermal infrared wavelengths over a range from about six to one hundred micrometers. The Stefan-Boltzmann equation relates infrared radiation to the temperature of a thermal black-body as

$$F = \sigma T^4$$

where F is the radiated energy flux, T is the black body temperature and σ is a constant. The equivalent black-body temperature of the earth as observed from space is 254 K or –19 °C. Obviously, the earth's surface temperature is not this cold. In fact the average surface air temperature is about 286 K or 13 °C. The reason for this warm surface temperature is well understood. The earth's surface, both land and water, emit thermal radiation. This thermal radiation is absorbed by the atmosphere, which in turn radiates energy back toward the surface, as well as to space. This downward radiation from the atmosphere, which we call the greenhouse effect, is responsible for the additional heating of the earth's surface that makes life as

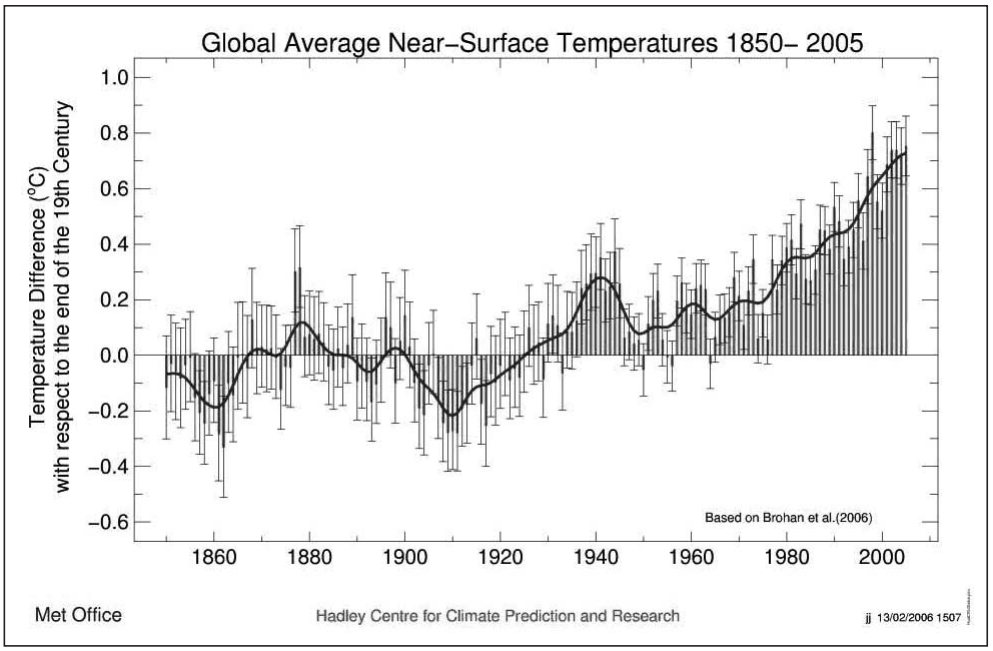

Figure 1. Surface air temperature plotted as a difference (in C) from the temperature from the value in 1900. The dark bars are the annual mean with the standard deviation indicated by the gray lines. The black curve is smoothed using a running average. (Courtesy of the Hadley Center, British Met Office, United Kingdom)

we know it possible. It is this radiation that prevents precipitous temperature drops at night or on very cloudy days.

The three principal greenhouse gases in the atmosphere are water vapor, carbon dioxide, and ozone. Water vapor is by far the most important, but the amount of water vapor in the atmosphere is closely regulated by temperature as described by the Clausius-Clapyron equation for saturation vapor pressure.[7] When the vapor pressure of water in any air parcel reaches the saturation vapor pressure, condensation occurs and the excess water is removed from the atmosphere as precipitation.

Unlike water vapor, the global, annual-average atmospheric carbon dioxide (CO_2) concentration is unaffected by the state of the atmosphere itself. In the absence of human activity, annual average CO_2 concentrations are stable on time scales of millennia, as we can determine from ice cores (more on this later). When CO_2 concentrations do increase, then the atmospheric greenhouse effect increases, the thermal infrared radiation from the atmosphere increases, and surface temperatures increase. Ozone concentrations peak at altitudes of 25 to 35 km (the stratosphere) above the earth's surface due to chemical processes. Consequently, ozone is relatively unimportant in regulating near-surface temperatures but is very important in regulating stratospheric temperatures.

Radiative transfer, the physics of radiant energy movement in the climate system, is very well understood. Given an adequate description of the properties of a column of atmosphere, we can compute the solar radiation reaching the surface to an accuracy better than a few percent. Similarly, we can compute the downwelling thermal infrared radiation from the atmosphere, the greenhouse effect, to a few percent. We can match calculated and measured infrared spectra (radiation measured as a function of frequency or wavelength) to the same level of accuracy, which demonstrates that we understand the detailed physics and chemistry of these gases. In fact, if we did not understand these processes as well as we do, we would not be able to make useful weather forecasts for more than a few hours.

We understand the role of greenhouse gases in regulating our current climate. It is important to ask whether we understand the role of greenhouse gases in past climate. This is an extremely interesting question, especially when considered over the total span of Earth climate history. Here we focus only on the last 500,000 years. Information on Earth history over this period comes primarily from ice cores. When snow compacts and turns to ice, small air bubbles are trapped in the ice. These bubbles retain the atmospheric composition of the time in which they were trapped in the column. So, if we drill an ice core in an undisturbed ice sheet, we can measure atmospheric concentration as a function of time. The longest ice core that we have is the Vostok core from Antarctica (Figure 3, p. 254). The 100,000 year cycles evident in this record are the Pleistocene ice ages. The most recent glaciation ended about 20,000 years ago and we are currently in a warm interglacial. The CO_2 curve exhibits a very similar behavior, indicating that Earth's temperature and CO_2 concentrations are intimately connected. Our current understanding of this trace of Earth climate history is that transitions between glacial and interglacial are triggered by changes in Earth's orbital parameters—the tilt of the earth's axis, the eccentricity (departure from sphericity) of the earth's orbit around the sun, and the precession of the earth's axis. CO_2 concentrations are part of a feedback loop where warmer temperatures release more CO_2, which then creates more warming through the greenhouse effect, which then releases more CO_2, etc. Thus, CO_2 concentrations are driving and are driven by temperature change on a geological time frame (millennia and longer).

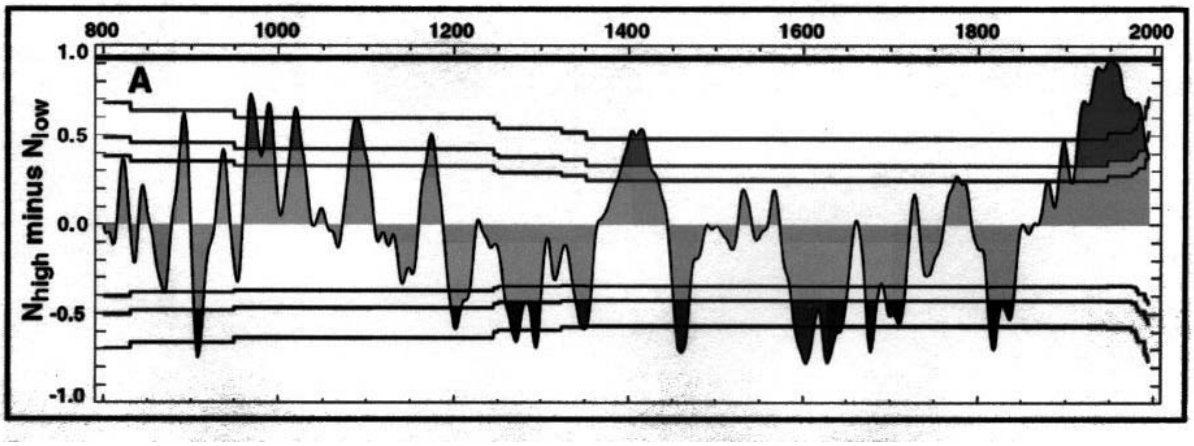

Figure 2. A statistical evaluation of temperature anomalies (difference from the mean) from climate proxies over the last 1200 years. Warm anomalies are shown as positive deflections and cold anomalies as negative ones. The solid lines represent confidence limits of 1, 2 and 3 standard deviations that the anomalies are not due to simple random events. The positive peaks around AD 1000 are the so-called Medieval Warm Period and the negative peaks from 1600 to 1850 are the Little Ice Age (from Osbourn and Briffa, *Science*, 2006).

Each American is currently responsible for adding five to six metric tonnes of carbon to the atmosphere each year through fossil fuel use. The aggregate of all this emission adds to the atmospheric burden of CO_2, which warms the planetary surface and atmosphere via the greenhouse effect.

What is the impact of human activities on greenhouse gas concentrations compared to those of natural processes? Can these activities impact global climate?

The current CO_2 concentration is 385 ppmv.[8] Human activity is currently increasing that concentration by a few ppmv every year (Fig. 4, p. 255). The CO_2 concentration began to increase from its pre-industrial value of 285 ppmv about 1850 and the rate of increase has accelerated with time. As we can see from the Vostok ice core record (Figure 3), CO_2 concentrations have varied between 180 and 280 ppmv over the last half million years. Thus, current values are the highest that have occurred in more than 500,000 years.

Natural variations in CO_2 concentrations can be seen in the annual cycle evident in Figure 4. The natural variability in the northern hemisphere summer is due to the annual growth of vegetation, which consumes CO_2, and in the winter, to respiration and decay, which releases CO_2. The average slope is the increase of CO_2 in the atmosphere due to the burning of fossil fuels. All combustion processes essentially turn carbon-based fuel and oxygen into H_2O (vapor) and CO_2.

The vast majority of natural atmospheric carbon has an atomic weight of 12, which scientists typically denote as ^{12}C. A very small percentage of atmospheric carbon is Carbon 14 (^{14}C), a naturally occurring radioactive carbon isotope with an atomic weight of 14. ^{14}C is produced in the atmosphere at a roughly constant rate by the influx of high-energy cosmic rays from the sun. A cosmic ray can combine with a ^{12}C atom to form a ^{14}C atom. Because the latter is naturally radioactive, it decays spontaneously to ^{12}C at a well-known rate.[9] All living organisms, including humans, contain small amounts of this naturally occurring radioactive ^{14}C. But, fossil fuel has no ^{14}C because any ^{14}C present at burial has decayed long ago and no additional ^{14}C is produced deep in the earth.

From measurements of isotopic ratios, we know that the ratio of ^{14}C to ^{12}C (the abundant stable isotope of carbon) in the atmosphere is currently decreasing. From this, we conclude that the additional CO_2 being injected into the atmosphere is primarily from fossil fuel rather than any changes in the natural carbon cycle. We also know the rate at which fossil fuel is produced and consumed. The increase in atmospheric CO_2 represents about 50–60% of the emitted CO_2 from fossil fuel. The remainder is dissolved into the mixed layer[10] of the ocean or stored in the biota on land.[11] Dissolving CO_2 into sea water produces carbonic acid. As a result,

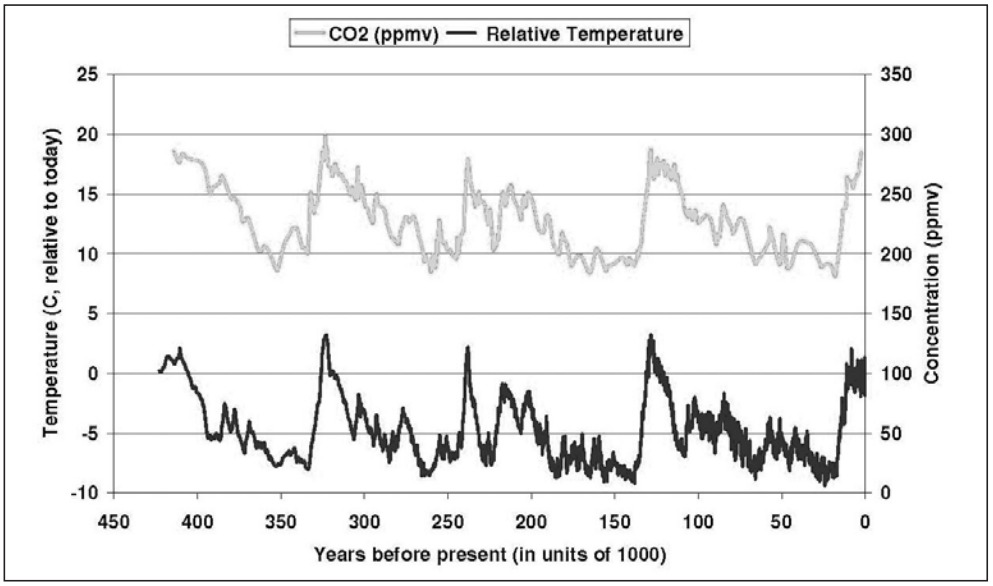

Figure 3. Data from the Vostok core drilled Antarctica. Times runs from left to right from 450,000 years before present to now. The temperature curve (lower) is calibrated in ° C relative to current temperatures.

the mixed layer is slowly becoming more acidic with potentially serious consequences for ocean ecosystems such as coral reefs.

The amount of carbon cycled into and out of the atmosphere each year exceeds the amount added in one year by human activity (Figure 4). These two processes, however, are very different in their long term impact. The annual cycle represents a nearly conservative process—the same amount of CO_2 is added to and removed from the atmosphere each year. The only way to alter this natural cycle is an absolutely massive change in the earth's biological productivity. Humans have altered the biomass through deforestation in the tropics, but have actually re-forested major pieces of North America during the last century. Human activity, on the other hand, is a one-way process. Each year we add a few more ppmv to the atmosphere, increasing the overall burden of CO_2 in the atmosphere.

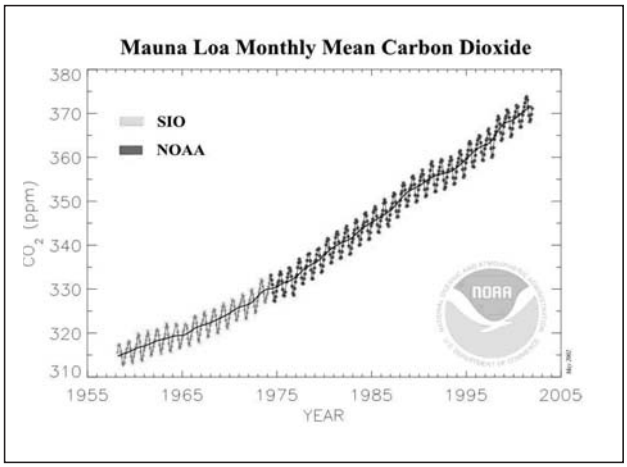

Figure 4. Monthly mean values of carbon dioxide measured at Mauna Loa Observatory, Hawaii. Data in the early years are from the Scripps Institution of Oceanography (SIO) and in the later years from NOAA. Similar curves with different annual cycles are available from Barrow, Alaska, American Samoa, and Antarctica.

One often hears the comment that human activity could not possibly affect climate because the earth is large and humans are small. We learned differently in the 1980s when we discovered decreasing ozone everywhere and the massive ozone hole over Antarctica. Ozone is indeed being destroyed by the chlorine and fluorine compounds that we were using for refrigeration and gaseous propellants. While each individual contribution was small, the number of humans is very large and the aggregate can affect our atmosphere. The same is true for CO_2. Human activity has increased the CO_2 concentration by 35% in the last one hundred years or so. Each American is currently responsible for adding five to six metric tonnes[12] of carbon to the atmosphere each year through fossil fuel use. The aggregate of all this emission adds to the atmospheric burden of CO_2, which warms the planetary surface and atmosphere via the greenhouse effect.

Can we predict climate change during this century? What confidence should we have in such predictions?

This is the critical question. We know that CO_2 is a greenhouse gas and warms the current climate system. Adding additional CO_2 (or any other greenhouse gas) to the atmosphere must warm the climate system, particularly the surface. The process is a bit like adding insulation to the attic of your house. If you put the same amount of heat into the house (the solar radiation into the planet), then the temperature in the house must increase because the insulation makes it more difficult to conduct that heat to the outside atmosphere. Adding more CO_2 to the atmosphere makes it more difficult for the earth's surface to radiate heat energy to space. So the real question becomes how much will the earth's climate system warm during this century as CO_2 concentrations increase?

Predicting the change in temperature for the earth's system due to increasing CO_2 is complicated because the earth's system is complex and climate is controlled by complex feedback loops. A feedback loop is a linkage of two (or more) components of a system that exhibit a round-trip information flow, i.e., changes in one produces changes in the other and vice versa. A detailed exposition of climate feedbacks is not possible here but a brief discussion is necessary.

The most important feedback loop in the climate system is between atmospheric temperature and water vapor. The amount of water in a parcel of air is limited by the saturation vapor pressure which is a function of temperature only. Thus, if we warm a parcel of air, we can evaporate more water vapor into that parcel. Saturation vapor pressure increases exponentially with temperature, and water vapor is the most potent greenhouse gas in the atmosphere. So, if the atmosphere warms, more water evaporates into the atmosphere, further warming the atmosphere and further increasing the amount of water. This loop is a positive loop because it enhances the original change. Water vapor feedback is so powerful that it amplifies the heating due to increasing CO_2 concentrations by a factor of two to four. Most positive feedback loops have some process that eventually stops the amplification. If not, the process becomes "runaway" and the system exhibits some form of catastrophic collapse. In the case of the atmosphere, a warmer atmosphere radiates heat energy more effectively to space. So, at some point, the increasing loss of radiation energy to space balances the increased radiational heating due to absorption by water vapor and prevents a drastic runaway.

A second, well-understood feedback loop is between temperature, ice cover, and solar radiation. Ice is highly

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reflective; it increases the solar reflectivity of the earth, also known as the earth albedo. If the earth warms, the amount of ice cover decreases, the reflectivity decreases thereby increasing the absorption of solar radiation and the earth warms further. This again is a positive feedback.

The most complex feedback loops involve clouds. Clouds regulate solar absorption by their reflectivity but also regulate infrared energy loss by enhancing the atmospheric greenhouse effect. In the current earth's climate system, clouds act to reduce the planetary surface temperature—their ability to reflect solar energy exceeds their ability to increase the greenhouse effect. The question for climate prediction is how will these two cloud effects balance in a warmer world. The short answer is that our current models indicate that clouds are overall a positive feedback, tending to amplify CO_2 warming. However, there is substantial uncertainty in that answer because cloud processes are very difficult to model, especially on a global basis.

Simulations of climate are made with a global climate model (GCM). A GCM is the best possible mathematical representation of all the processes that affect climate in the atmosphere, ocean, and cryosphere (ice on land and ocean), as well as some of the biological connections. Because these equations cannot be solved analytically, they are solved computationally on a global mesh. The typical horizontal dimension of that mesh is 100–300 kilometers, which translates into some 8,000 to 10,000 grid squares on the earth's surface. The atmospheric column above each square is typically divided into twenty-five to thirty layers. We solve equations in each layer in each box for temperature, humidity, three components of the wind, and pressure (or height since pressure is usually the vertical coordinate of choice). The global domain and the intricate physics and chemistry of climate make GCMs among the most computationally intensive and complex computer codes ever written.

But climate models are at the same time too coarse in resolution to describe what we actually know about cloud processes, chemistry, and surface interactions over land and ocean. The limits of resolution are primarily dictated by computer time. Increasing the resolution of a model by a factor of two (say, going from 200 to 100 km in horizontal resolution) essentially increases the computational time to run a model by a factor of ten. Since we are already stressing the largest computers in the world, increasing computational burdens by a factor of ten to one hundred or more is simply not possible at this point. This lack of resolution results in two major problems. The first is a lack of regional specificity in our simulations. Our current models cannot adequately simulate the actual complexity of land features such as mountains and coastlines, which limits the ability of the models to capture regional patterns of temperature and precipitation. The second is an increase in overall model uncertainty because sub-gridscale processes must be represented through parameterization rather than through explicit physical and chemical equations.

Clouds are a good example of this problem. The physics of cloud formation occurs on spatial scales from micrometers to hundreds of meters. These processes cannot be resolved by the coarse spatial grids of a GCM, so our models use statistical representations of clouds based on the model-predicted average values of wind, temperature, and moisture at a scale of one hundred kilometers or more. Because the statistical representations or parameterizations are not based exclusively on fundamental physics equations, they are not unique descriptors and vary from model to model depending on the best understanding of the model designers. This in turn introduces uncertainty into the models. Most importantly, it affects the strength of the cloud feedback loops and thereby introduces uncertainty into our simulations of future climate.

Given these factors, what can we say about climate change over the next century? Actually, we can say quite a bit! We have run our current GCMs for the current climate, particularly focusing on the last 150 years. When supplied with the combination of natural climate forcing (small variations in the incoming solar flux and volcanic aerosol) and human forcing (increasing greenhouse gas concentrations, changes in air quality, and changes in land surface cover), the models do a very credible job of predicting global surface temperature change over the past 150 years (Figure 5). Logically, this model

prediction of past climate is a necessary rather than sufficient condition. It is possible for a climate model to get the "right" answer for the "wrong" reason. Given the complexity of the models and the climate system itself, however, this degree of agreement gives us high confidence that the models are simulating climate correctly.

In order to ask what the future holds, we need to create scenarios of changes in climate forcing over the next century. These scenarios are essentially projections of population growth, economic development, and energy usage. Any individual scenario has large uncertainties so models are typically run for a series of scenarios based on a range of assumptions from "business as usual," which results in very large carbon emissions, to environmentally friendly, which reduces human carbon emissions to near-zero by later in the century. All climate models and all scenarios produce significant climate warming of 2–4 °C in surface air temperature by 2100 or sooner (Figure 6). The differences between scenarios (heavy lines) are considerably greater than the differences among models for a given scenario (shaded regions). This suggests that the models, although they have some differences, are largely consistent in their prediction of future climate warming.

The lowest curve in Figure 6 is also noteworthy. This curve represents the evolution of Earth's climate if the CO_2 concentration were fixed at the year 2000 level. The climate continues to warm because there is a large thermal lag in the warming of the ocean. Climate scientists call this the "commitment" that we have made to climate warming through the addition of CO_2 and other greenhouse gases to the atmosphere. Even if we are able to stop the addition of greenhouse gases to the atmosphere at some time in the future, the climate system will continue to warm for an extended period of time.

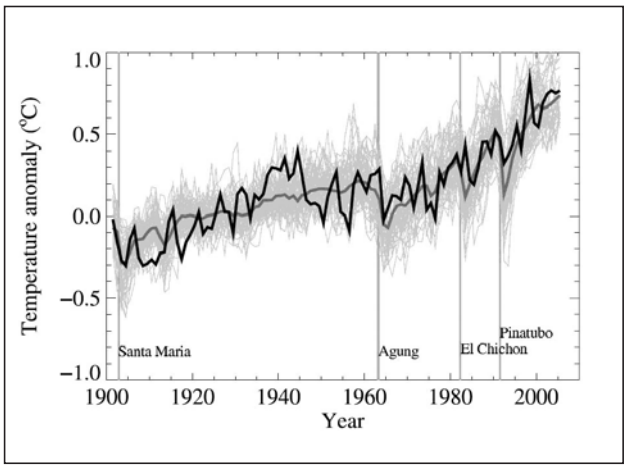

Figure 5. Global mean near-surface temperatures over the twentieth century from observations (heavy peaked line) and from fifty-eight simulations produced by fourteen different climate models driven by natural and human-caused factors that influence climate (grey background area). The lighter smoothed line depicts the mean of all fifty-eight runs. Temperature is plotted as the difference from the average from 1901 to 1950. Vertical grey lines indicate the timing of major volcanic eruptions. (Figure 8.1, IPCC Working Group 1, "Fourth Assessment Report.")

Global surface air temperature is a simple but convenient way to represent climate change. In discussing climate change, the IPCC report[13] identifies a large number of changes that models predict over this century. A short list includes:

- Sea level rise of two to three feet by the end of the century due to thermal expansion of the ocean (water expands in volume when heated), and possibly much larger increases if significant melting of the Greenland and/or the West Antarctic ice sheets occurs
- Further drying of the sub-tropical dry zones such as the Sahel and the Mediterranean Basin, leading to increased stress on arid land ecosystems
- Increased rain and increased rain intensity in mid-latitude rainbelts, leading to higher probability of extreme flood events
- Increases in Arctic region temperatures that are two to three times the global average, producing longer growing seasons, significantly more melting of the permafrost, loss of Arctic sea ice, and significant stresses on natural Arctic ecosystems
- Ocean acidification inhibiting the formation of carbonate shells by small sea creatures and causing perhaps irreversible damage to coral reef ecosystems when coupled with warming ocean temperatures

In any such list one can identify changes that may be regionally positive, but the bulk of the changes that

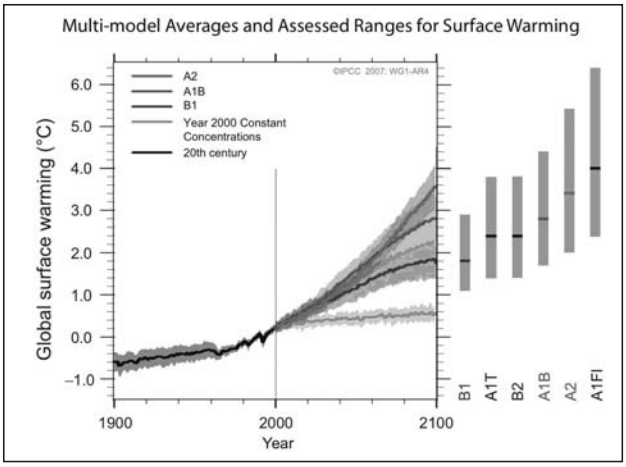

Figure 6. Global climate model simulations of projected climate change. A2, A1B, and B1 are differing scenarios of greenhouse gas emissions. Solid lines are the average of simulations by different models and the shaded areas represent one standard deviation in the model results. The bars at the right (dark line) provide best estimate and likely ranges at 2100 for all climate models as well as other techniques for estimating climate change due to greenhouse warming. The bottom curve shows warming over this century with greenhouse gas concentrations held constant at their year 2000 values. (Based on Figure SPM.5, IPCC Working Group 1, "Summary for Policy Makers.")

Among [the evangelical Christian] community, one can identify five general categories of respondents to the issue of global warming: (1) Cock-eyed optimists; (2) End-time militants; (3) Denialists; (4) Creation care proponents; and (5) Social justice advocates.

we have identified are clearly negative. Recently, NASA Administrator Michael Griffin opined:

> I guess I would ask which human beings—where and when—are to be accorded the privilege of deciding that this particular climate that we have right here today, right now is the best climate for all other human beings. I think that's a rather arrogant position for people to take.[14]

This view of climate change ignores the fact that natural ecosystems and human civilization have spent hundreds to thousands of years adapting to the current climate and will not easily adapt to rapid climate shifts over the short span of a century.

There is much more that can and has been said about climate change that awaits us over this century. The clear message from the climate science community is that, if we continue to add greenhouse gases to the atmosphere, warming will occur at a rate unprecedented in the last 10,000 years leading to global average temperatures warmer than at any time in the last 500,000 years. This warming will have large, but still somewhat uncertain, consequences for regional climate, particularly water resources. Most of these consequences will have negative impacts on the evolved natural ecosystems and human civilization. Ocean sea level rise and acidification will be harmful to coastal zones and small island countries, particularly in the tropical oceans. The Arctic region will see the most profound changes in climate and associated impacts on ecosystems and sustainability.[15]

Christian Responses to Climate Change

Our knowledge of climate science and understanding of CO_2-driven climate change has increased enormously over the past three decades. The preceding section is a very brief summary of the huge body of material summarized and cited in the IPCC reports. Textbooks containing more extensive summaries are appearing rapidly.[16] For the most part, the world community has accepted the conclusions of the world scientific community as embodied in the IPCC reports. The Kyoto protocol, which seeks to begin the process of reducing CO_2 emission, was signed in 1997 and has been ratified by 175 parties, including all of the developed countries of the world with two exceptions, Australia and the United States of America.

In the United States, opponents of the science of global warming go well beyond opposition to the Kyoto protocol alone to oppose the science itself and the attribution of current climate trends to increased greenhouse gases. The opponents come largely, but not exclusively, from the political right. Although there is no doubt that a large share of the opposition is driven by certain sectors of the business community (see, e.g., the editorial pages of the *Wall Street Journal* or the website of the Competitive Enterprise Institute), some members of the business community, including Ford Motor Company and General Motors Corporation, are beginning to address the greenhouse gas issue.[17] Another significant share of the opposition, however, is drawn from the evangelical Christian community, the same community that supports such organizations such as the Christian Coalition of America and the Family Research Council. Recently, some fractures have occurred in this community as well, which raises the question of why this opposition has occurred and why some fractures are appearing now.

There is not a clear consensus on the definition of "evangelical." I use it here to refer to those Christians that believe in the sole authority and infallibility of the Bible, salvation only through the work of Jesus Christ, and a spiritually transformed personal life. The evangelical community includes most of the Baptist churches, Pentecostals, many independent community churches, and several small Presbyterian and Reformed denominations that have split off from the older mainline Protestant denominations. As a general rule, the evangelical Christian community is strongly aligned politically with the Republican party and very vocal on perceived issues of family and values. Among this community, one can identify five general categories of respondents to the issue of global warming:

1. Cock-eyed optimists
2. End-time militants
3. Denialists
4. Creation care proponents
5. Social justice advocates

I apologize in advance for the broad brush strokes used to describe briefly these positions, but some generalization is inevitable.

Cock-eyed Optimists. Evangelicals proclaim the goodness of God. Consequently, there is an implicit understanding in their worldview that God will provide for his people and that events in this world happen under God's control. Interpreting this statement in the presence of obvious evil and injustice in the world is one of the great intellectual challenges of Christianity. Some evangelicals tend to resolve this problem by simply declaring that God will provide all a believer's needs if he or she follows God's commandments. They also often argue that the United States has achieved its prosperity and strength because it is (or has been) a "Christian" nation blessed by God.

They take a similar position in discussions of the earth's resources and population. For example, *America's Providential History* states:

> A secular society lacks faith in God's Providence, and consequently men find fewer natural resources. The secular or socialist has a limited-resource mentality and views the world as a pie (there is only so much) that needs to be cut up so that everyone can have a piece. In contrast, the Christian knows that the potential in God is unlimited and that there is no shortage of resources in God's earth.[18]

It is a simple step from this statement to conclude that the climate change issue is simply not a problem—God will provide. This particular view is popular with Christians who find climate change science difficult to understand and are conflicted by the multitude of opinions being heard within the Christian community. One trusts in God and therefore can dispense with the details.

Contemporary commentators from outside the evangelical community frequently refer to this position with bewilderment. In a recent column in the *Seattle Post-Intelligencer*, Mark Trabant wrote:

> If you believe in literal truth—and the absolute, personal power of a Creator—then it doesn't really matter if we humans have fouled our own nest. We'll be taken care of later. That is a harsh way of dismissing the teaching of science, experimenting with stem cells or global warming.[19]

Few evangelicals would agree with this brutal characterization of their position, but it is worth pondering how this characterization came to exist.

End-time Militants. Believers in the Second Coming of Jesus Christ have long debated the chronology of events associated with the end times as deduced from biblical apocalyptic literature, particularly the Books of Daniel and Revelation. At one time, American Protestantism featured a range of positions on this chronology, differentiated to some degree by differences in opinion about the timing of the Millennium, the 1,000 year reign of Christ at the end of time. During the last century, particularly the latter part, evangelicals in America became heavily invested in dispensational pre-millennialism with its strong emphasis on a literal interpretation of apocalyptic biblical literature, identification of current events as signs of the end times, and predictions of an imminent rapture. Even a cursory perusal of the dispensationalist (which has become the catch-word for pre-millennial adherents) media outlets whether in print, over the airwaves, or on the internet demonstrates that dispensational believers have also become extremely militant about their position on the end times, essentially declaring that no other position is biblically defensible.

The end-time militants are largely anti-environmentalists on two grounds. The first is fairly obvious. If the end is near, then why would one worry about preserving the climate of a planet that is soon to be destroyed by the wrath of God in the giant battle of Armageddon? In an article on his "Rapture Ready" website, Todd Strandberg writes:

> In 2 Peter, we are told that someday the earth will undergo a fiery renovation. All of nature and everything man has created will be completely destroyed … I know that environmentalists would bristle at the idea of a refurbished earth being the ultimate solution to all ecological problems. If the world is going to be "dissolved," there is no need for us to become too attached to it.[20]

This statement is not unique; similar comments are quite easy to find. Strandberg is willing to carry this argument even further. In the same article, he writes:

> The main job of a Christian leader is to guide lost souls to redemption … In my view, any preacher who decides to get involved in environmental issues is like a heart surgeon who suddenly leaves an operation to fix a clogged toilet.[21]

In a thought-provoking article published in 2004 on the website grist, Glenn Scherer points out:

> Forty-five senators and 186 representatives in 2003 earned 80- to 100-percent approval ratings from the nation's three most influential Christian right advocacy groups—the Christian Coalition, Eagle Forum, and Family Resource [sic] Council. Many of those same lawmakers also got flunking grades—less than 10 percent, on average—from the League of Conservation Voters last year.[22]

His interpretation of these statistics is that the legislators' anti-environmentalism is derived from their end-time theology based on a literal reading of apocalyptic literature. This is a logical deduction but one that is difficult to substantiate because most politicians do not provide explanations for their legislative votes based on religious grounds.

[Cock-eyed optimists and end-time militants] choose not to deal with the issue of global warming although their reasons for not doing so are different. The creation care and social justice groups … recognize the scientific basis of global warming and are convicted of the need to act now. The denialists are united by their rejection of global warming.

One might argue that this split is party driven or largely tied to the perception that legislation favored by the Conservation Voters is anti-business, while the Christian right tends to be very pro-business. I think, however, that it is worth considering the role end-time theology plays in producing an anti-environment bias among legislators who are also evangelical Christians.

The second ground is perhaps even more difficult for those not familiar with dispensational theology to understand. Most end-time militants are convinced that the anti-Christ, the leader of the forces that will be arrayed against God at the end times, will be the representative of some world government. Quoting from again Strandberg:

> The true goal of the environmental movement is to draw the world into a central body that would set the rules. This plan is part of the devil's master scheme to recreate the type of control he had during the time of the Babylonian Empire. The only way to get back to Babylon is to push for world unity. The environmental movement is a perfect disguise because it asks nations to surrender their sovereignty for a cause seemingly beneficial to all nations.[23]

While Strandberg states this more bluntly than many, there is no doubt that a large majority of end-time militants sees the environmental movement as a monolithic force diametrically opposed to their religious beliefs.

End-time militants represent the most fervent evangelical opposition to the environmental movement in general and climate change in particular. Concerns about climate change are often literally seen as the work of the devil because the subject detracts from efforts to spread the Gospel, which is the only task of Christians given the imminence of the Second Coming, and because it supports the growth of the anti-Christ coalition. Those not familiar with dispensational theology may find this all to be seriously strange thought, but it is crystal clear to dispensational evangelicals.

Denialists. On July 28, 2003, Senator James Inhofe of Oklahoma concluded a speech on the floor of the Senate by stating:

> With all of the hysteria, all of the fear, all of the phony science, could it be that manmade global warming is the greatest hoax ever perpetrated on the American people? It sure sounds like it.[24]

While Inhofe resides in Tulsa, OK, and has a long record of support for the oil and gas industry coupled with extreme anti-environment positions, he is also a fundamentalist Christian.[25] His comments represent another common evangelical position on climate change, one often coupled closely with the end-times response.

The Interfaith Stewardship Alliance (ISA), principally organized by Calvin Beisner of Knox Theological Seminary, is probably the leading expositor of this position.[26] Beisner and his colleagues argue that (1) recent and foreseeable climate change are largely natural in cause rather than the result of human activity, (2) climate change over this century will be moderate rather than catastrophic, (3) increased CO_2 will be good for plants and thereby help feed the world, (4) current plans such as Kyoto protocol would not produce significant mitigation, and (5) such efforts would seriously hurt the world's poor. These particular arguments are not novel nor confined to the ISA and its proponents. After all, there are denialists in the United States that are not connected in any way with the evangelical Christian community. The difference is that the ISA seeks to wrap its denialist position in a mix of biblical citations, free enterprise litany, and nationalistic flag-waving (see, for example, its Cornwall Declaration[27] which it asks evangelicals to sign and support).

It is difficult to characterize clearly evangelical denialists and their motives. In some cases, it seems that the primary motivation is a deep distrust of science in general and Earth and biological sciences in particular. This strain runs deeply through the fundamentalist wing of the evangelical community. Their distrust of science arises from issues such as evolutionary biology and the age of the universe. They have concluded that for the most part scientists are godless liberals intent on destroying the faith community and therefore cannot be trusted on environmental issues. Ergo, climate change is indeed a hoax, as Inhofe proclaimed.

Other groups, such as the ISA, attempt to present the denialist point of view as legiti-

mate scientific inquiry. Much like the creation science community, climate change deniers like to portray themselves as the true scientists who are being persecuted intellectually by the mainstream scientific community as a result of a grand conspiracy. Conspiracy theories are one of the mainstays of the far right, so this particular idea often resonates well with the fundamentalist wing that distrusts science in any case. It is difficult to tell whether groups such as the ISA truly believe the denialist science they cite or whether they find it convenient because it supports their already determined theological perspective. In either case, they provide a pseudoscience patina that allows a sizeable segment of the evangelical Christian community to oppose any action on climate change as premature due to "scientific uncertainty."

Perhaps the most interesting developments in the denialist perspective are the twin arguments that CO_2 is good for the earth and that environmental concerns and actions will hurt the poor. As we will see shortly, these two arguments arise as direct contradictions to positions argued by evangelicals that take climate change as a serious problem.

Creation Care Proponents. In all the discussions of the Christian relationship to the environment, there is no Bible verse cited more often than Genesis 1:28: "*God blessed them and said to them, 'Be fruitful and increase in number; fill the earth and subdue it. Rule over the fish of the sea and the birds of the air and over every living creature that moves on the ground'*" (New International Version).

There are a broad range of interpretations that surround this verse. Much of this discussion has centered on the idea and meaning of stewardship in the context of creation. The Calvinist tradition has a long history of grappling with this issue. While there are examples where the Calvinist interpretation has led to exploitation, there are also many examples, such as the Au Sable Institute,[28] where stewardship has produced active support for environmental preservation. The climate change issue is bringing new voices and new perspectives into alignment with these existing structures under the rubric of creation care.

We could select any number of organizations and statements to illustrate the creation care position. We have selected two that represent somewhat different perspectives on the creation care position. The first organization is the Evangelical Climate Initiative (ECI). In its statement on climate change, ECI claims:

> Christians must care about climate change because we love God the Creator and Jesus our Lord, through whom and for whom the creation was made. This is God's world, and any damage that we do to God's world is an offense against God Himself (Gen. 1; Ps. 24; Col. 1:16).[29]

The ECI and the closely allied Evangelical Environmental Network (EEN)[30] are driven in large part by creation care (as attested by the website name of the EEN). Their response to this mandate is to motivate the evangelical community to deal with the climate change issue by organizing within the evangelical community and interacting with the political sphere.

The second organization is Restoring Eden. Its mission statement states:

> Restoring Eden makes hearts bigger, hands dirtier, and voices stronger learning to love, serve, and protect God's creation. Restoring Eden lives out the biblical mandate to "speak out for those who cannot speak for themselves" (Proverbs 31:8) as grassroots activists advocating for natural habitats, wild species and indigenous cultures.[31]

While the focus of Restoring Eden is on creation care, this focus is more personal and less organizational than ECI. This position resonates with many evangelicals, especially the young, who are in general wary of organizational structures.

For many evangelicals, creation care provides a very strong motivation to be engaged in discussions about and finding solutions to the climate change problem. This motivation is driven by the conviction that the climate change problem is real and the consequences are potentially severe. The contrast with the denialist camp as typified by the ISA is not so much in the area of the creation care mandate itself, which both subscribe to, but in the understanding of climate change as a critically important issue of our time.

Social Justice Advocates. In the context of Christian ethics, there is no more compelling text in the Bible than Micah 6:8: *"He has shown all you people what is good. And what does the LORD require of you? To act justly and to love mercy and to walk humbly with your God"* (Today's New International Version).

Evangelicals have wrestled for many years with how to live this commandment. What does it mean to act justly and to love mercy, especially to those who come from different cultures, races, and social and economic systems? While some parts of the evangelical community, particularly educational institutions like Calvin College and Wheaton College, have openly examined and debated these questions for years, many evangelicals have avoided them. Part of their discomfort was the often expressed opinion that the social gospel of the early twentieth century was the death knell for religious orthodoxy among the mainline Protestant denominations. Hence, any movement toward social justice would ultimately produce the same slide among current evangelicals.

Ironically, the rise of the religious right and the moral majority may be in part responsible for a renewed

From my perspective, Christians have a clear and compelling call to action … We must take leadership in articulating the ethical standards on which actions are based, determining the technical solutions that are most consistent with our standards and most effective in meeting the needs of the less fortunate, and demanding political action on local, state, and national levels.

emphasis on social justice among evangelicals. If some parts of the evangelical community could align itself with political parties and issues, then why not speak on issues of social justice? Evangelicals like Jim Wallis of *Sojourners* magazine speak cogently on social justice issues and challenge other evangelicals to do so. Some mega-church pastors such as Rick Warren of Saddleback Church have moved from a dominant focus on church growth and personal piety to address issues of social justice. The Evangelical Climate Initiative reflects this progression of thought. In its statement on climate change, the ECI makes the claim:

> Christians must care about climate change because we are called to love our neighbors, to do unto others as we would have them do unto us, and to protect and care for the least of these as though each was Jesus Christ himself (Matt. 22:34–40; Matt. 7:12; Matt. 25:31–46).[32]

Social justice in the context of climate change resonates far beyond the evangelical community. It is a keystone concept in the theology of many of the liberal Protestant churches, as well as some segments of the Roman Catholic Church. In the secular community, there is a growing body of literature on the ethics of climate change that addresses inter- and intra-generational equity. The former essentially focuses on the issue that it is the poor and those with the fewest natural resources that suffer the most from climate change and will continue to do so. The latter speaks to the legacy this current generation is leaving for succeeding generations. Evangelicals have a great deal to offer to these discussions of equity and are beginning to take a more active role in them.

As with the creation care issue, denialists tend to agree with the broad concepts of equity but take exception to the idea that it is the poor who will suffer most. This position is clearly at odds with the vast majority of literature on the subject[33] and difficult to defend sensibly. Countries like the United States and those of Western Europe have the wealth, technological expertise, and infrastructure to mitigate climate change impacts. All three of these are lacking in poor countries in the African Sahel and Southeast Asia or countries with very limited resources and options such as the Pacific Island nations. The ISA group is correct in identifying the need to increase investment and provide cost-effective energy to these countries. It is incorrect in assuming that this cannot be done while addressing the profligate carbon emissions of the wealthy.

In this section, I have tried to delineate five responses, but these five could, in some sense, be grouped into three. The first two groups basically choose not to deal with the issue of global warming although their reasons for not doing so are different. Some members of these groups make common ground with the denialists in arguing that the science of global warming is questionable, but this is not their principal motivation. To a large degree, their theological position is that global warming is not important, regardless of the science. The creation care and social justice groups show considerable overlap. They recognize the scientific basis of global warming and are convicted of the need to act now. Their theological motivations are somewhat different but both groups tend to acknowledge the perspective of the other as ethically and morally sound.

The denialists occupy a middle ground between the other two in some ways but are the most difficult by far to categorize. They are united by their rejection of global warming science. They often couch this rejection in pseudo-scientific language and arguments, most of which they borrow from other communities. It is difficult to know whether they reject the science on the basis of these pseudo-scientific arguments or whether they use them to bolster a pre-existing religious bias against science in general and global warming in particular. Regardless, their position is clearly at odds with scientific evidence and understanding of global warming. That does not seem to bother them, in part because they view scientists as largely irreligious and hopelessly biased in favor of global warming. On general theological grounds, they almost always support the creation care principle and sometimes support issues of social justice. They avoid applying these to the global warming problem by denying that it is important. One suspects that this position will become increasingly more untenable as the evidence for and scientific basis of global warming continues to increase.

A Personal Statement

Climate change due to increases in atmospheric greenhouse gas concentrations is real and is occurring now. The scientific understanding of the problem is robust and the projections of global change in this century are consistent and reproducible across differing models and methods. There is no longer any serious debate about these statements in the scientific community because there is no credible scientific evidence or model studies to support an alternate view.[34]

The projected changes are potentially devastating to our world. Global temperature increases of 2–4 °C, as projected for this century, are well outside any changes seen in the last 1,000 years and most probably in the last 10,000 years of Earth's history. A global temperature increase of this magnitude and rapidity will translate into even larger regional changes in temperature and available water, stressing natural ecosystems and human environments. The suggestion that such changes would be benign is based on misguided hope rather than any realistic evaluation.

We, the developed countries of the world, bear major responsibility for this situation. We are emitting and have emitted the bulk of the excess greenhouse gases in the atmosphere. Our lifestyles are energy intensive and powered by prodigious fossil fuel consumption. Each American is responsible each year for the addition of more than five tonnes or 5000 kilograms of carbon to the atmosphere.

There are solutions to this problem, although I have not discussed them here. The solutions are not easy or cheap, but neither are they so difficult or expensive as to preclude application. Interested readers are invited to consider the wedge technology solutions of the Carbon Mitigation Initiative at Princeton University[35] as one viable approach.

We in the developed countries are the major source of the problem. Do we, therefore, bear a specific responsibility to solve the problem? This is the crux of the ethical question. If we deny that there is a problem, then of course there is no need for a solution. Americans as a nation are not attempting to solve the problem. In fact, we are obstructing the adoption of solutions through denial and procrastination, especially at the federal level.

If we agree that global warming presents a large risk to planet Earth and its inhabitants, then must we act? What is our motivation for doing so? From my perspective, Christians have a clear and compelling call to action. We are commanded to love our neighbors and to seek their welfare above our own. Putting our poorer neighbors at risk in this generation and our children (and others) at risk in the next generation is incompatible with the second of the great commandments. We are also commanded to care for God's creation, a command which Christians ought to take seriously. Putting the flora and fauna of the planet at risk by our actions is incompatible with an ethos of climate care and stewardship. On the global warming issue, evangelical Christians have largely failed to take ownership or leadership. It is past time for this to change. We must take leadership in articulating the ethical standards on which actions are based, determining the technical solutions that are most consistent with our standards and most effective in meeting the needs of the less fortunate, and demanding political action on local, state, and national levels. We can do no less. ✯

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Notes

[1]The International Panel on Climate Change (IPCC) has recently issued its 4th Assessment Report on climate change. Summaries and complete reports are available at www.ipcc.ch Last accessed 12 September 2007.

[2]For example, the United Nations Framework Convention on Climate Change (1992), http://unfccc.int/essential_background/convention/items/2627.php Last accessed 12 September 2007; and the Kyoto Protocol to the United Nations Framework Convention on Climate, Kyoto (1998), http://unfccc.int/kyoto_protocol/items/2830.php Last accessed 12 September 2007.

[3]Evangelical Climate Initiative, *Climate Change: An Evangelical Call to Action*, www.christiansandclimate.org/statement Last accessed 12 September 2007.

[4]Interfaith Stewardship Alliance, *An Open Letter to the Signers of "Climate Change: An Evangelical Call to Action,"* www.interfaithstewardship.org/pages/article.php?&id=160 Last accessed 12 September 2007.

[5]I am an old-earth creationist. All credible evidence from astronomy, solar physics, planetary science, and Earth science supports this position. The only scientifically tenable position for a young-earth creationist is to argue that God created the earth with an appearance of great age, which is inconsistent with my understanding of the attributes of God.

[6]IPCC, 4th Assessment Report, see especially the Summary for Policy Makers and chapters 3–5 of *Working Group 1: The Physical Basis of Climate Change*.

[7]Atmospheric pressure is a measure of the total force exerted by a column of atmospheric gases. The vapor pressure of water is the force exerted by the water molecules only. Thus, in any atmospheric parcel, the vapor pressure of water is some fraction, usually small, of the total pressure. The amount of water in an atmospheric parcel is limited by the saturation vapor pressure, which is a function only of the temperature of that air parcel. If the vapor pressure of a parcel reaches the saturation vapor pressure, condensation must occur and vapor is converted to liquid water (or ice). Meteorologists often report vapor pressure in terms of relative humidity, which is the ratio (in %) of the observed vapor pressure to the saturation vapor pressure. At 100% relative humidity, condensation must occur.

[8]Part per million by volume (ppmv) is a measure of the number of CO_2 molecules in one million molecules of air.
[9]The decay rate is typically reported as a "half-life," the time it takes for an initial number of radioactive molecules to decay to ½ their initial number. The half-life of ^{14}C is about 5,700 years.
[10]The mixed layer of the ocean is the top 60–100 m of water that is closely coupled to the atmosphere by fluxes of energy and water at the ocean surface. Deep ocean water is much colder and saltier and largely disconnected from the atmosphere.
[11]Perennial plants such as trees sequester carbon in their biomass, thus removing it from the atmosphere. As part of this same growth process, carbon ends up in soils as organic matter.
[12]A metric tonne is 1000 kilograms, or approximately 2,200 lbs.
[13]IPCC, 4th Assessment Report, see especially the Summary for Policy Makers and chapters 10 and 11 of *Working Group 1: The Physical Basis of Climate Change*.
[14]Interview with Steve Inskeep on Morning Edition, National Public Radio, June 7, 2007.
[15]Arctic Climate Impact Assessment Project, *Impacts of a Warming Arctic* (2004): www.acia.uaf.edu Last accessed 12 September 2007.
[16]See, for example David Archer, *Global Warming, Understanding the Forecast* (Malden, MA: Blackwell Publishing, 2007) or Andrew Dessler, *The Science And Politics Of Global Climate Change* (Cambridge: Cambridge University Press, 2006)
[17]United States Climate Action Partnership, www.us-cap.org/index.asp Last accessed 12 September 2007.
[18]S. K. McDowell and M. A. Beliles, *America's Providential History* (Charlottesville, VA : The Providence Foundation, 1989).
[19]Mark Trabant, *Seattle Post-Intelligencer*, May 6, 2007.
[20]Todd Strandberg, "Bible Prophecy and Environmentalism," www.raptureready.com/rr-environmental.html Last accessed 12 September 2007.
[21]Ibid.
[22]Glenn Sherer, "The Godly Must be Crazy" (October 27, 2004), www.grist.org/cgi-bin/printthis.pl?uri=/news/maindish/2004/10/27/scherer-christian/index.html Last accessed 12 September 2007.
[23]Todd Strandberg, "Bible Prophecy and Environmentalism."
[24]James Inhofe, Senate Floor Statement, July 28, 2003, http://inhofe.senate.gov/pressreleases/climate.htm Last accessed 12 September 2007.
[25]I use fundamentalist here to distinguish those evangelicals who believe in an infallible Scripture and read Scripture literally. This position leads to positing a young earth and extreme opposition to almost all facets of biological evolutionary theory.
[26]Interfaith Stewardship Alliance, see statements at www.interfaithstewardship.org/pages/home.php Last accessed 12 September 2007.
[27]Cornwall Declaration (2005), www.interfaithstewardship.org/pages/cornwall.php Last accessed 12 September 2007.
[28]Au Sable Institute of Environmental Studies, www.ausable.org/au.main.cfm Last accessed 12 September 2007.
[29]Evangelical Climate Initiative, *Climate Change: An Evangelical Call to Action*.
[30]Evangelical Environmental Network, www.creationcare.org Last accessed 12 September 2007.
[31]Restoring Eden, www.restoringeden.org Last accessed 12 September 2007.
[32]Evangelical Climate Initiative, *Climate Change: An Evangelical Call to Action*.
[33]See, for example, *Climate Change 2007: Impacts, Adaptation and Vulnerability*, IPCC Working Group II Report and references therein, www.ipcc.ch Last accessed 12 September 2007.
[34]This statement is likely to be challenged by the denialist camp. My point is that science proceeds by analysis of data and mathematical modeling. The scientific community has analyzed and modeled alternate theories such as solar variability, long-term natural cycles, cloud nuclei produced by cosmic rays, etc. None of these has stood up under peer-reviewed scrutiny and therefore these theories are not considered credible by the scientific community.
[35]www.princeton.edu/~cmi Last accessed 12 September 2007.