Seven Theories of Climate Change

by Joseph L. Bast

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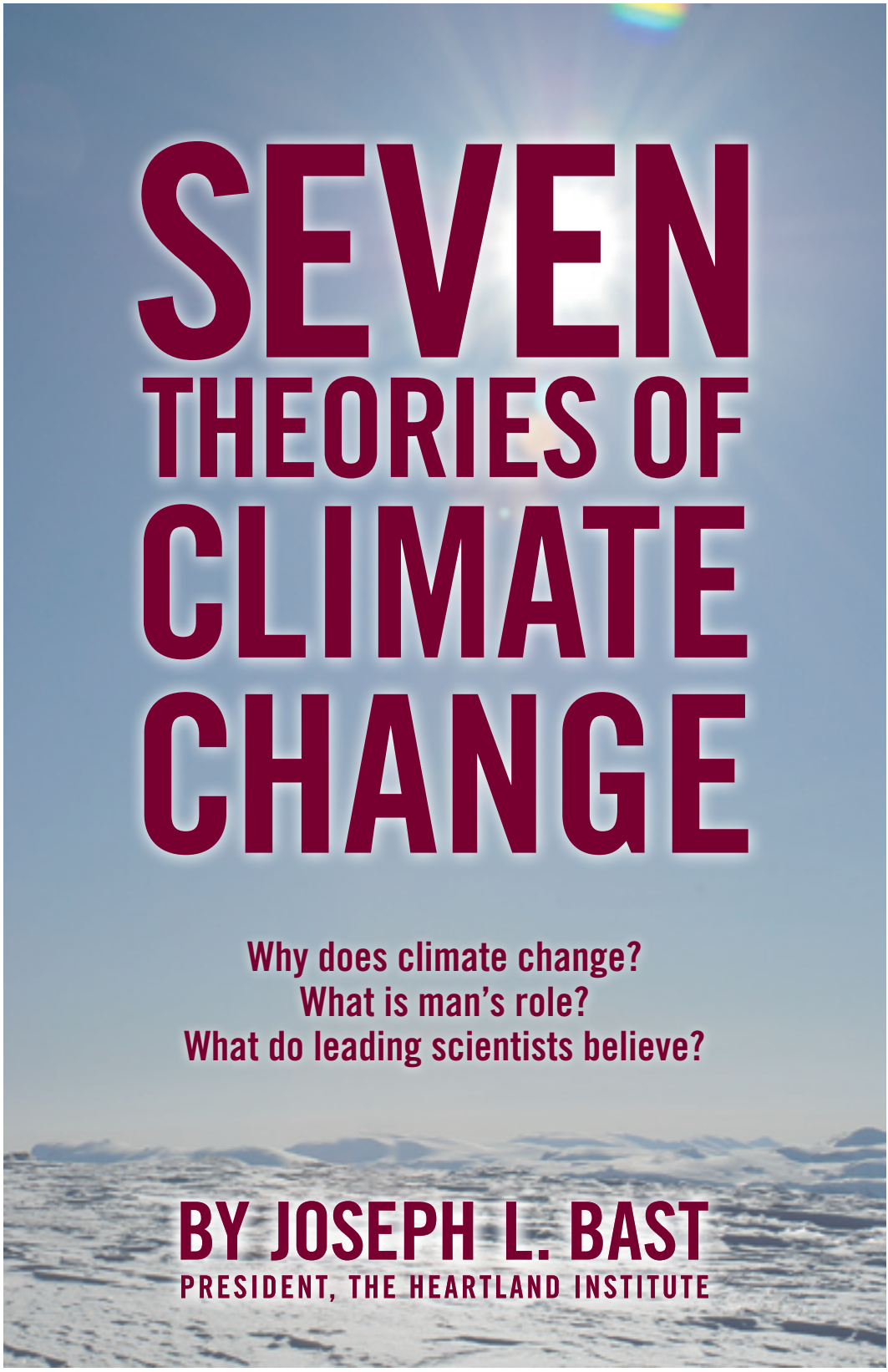
SEVEN
THEORIES OF
CLIMATE
CHANGE
Why does climate change?
What is man's role?
What do leading scientists believe?
BY JOSEPH L. BAST
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Seven Theories of Climate Change

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Acknowledgments

The fixation on a single theory of climate change during the 1990s and early years of the twenty-first century damaged the careers of many fine scientists who saw through the popular delusion and courageously spoke the truth. This booklet is dedicated to them.

The author thanks the following reviewers for their comments on early drafts of this booklet: William F. Gray, Jay Lehr, Richard S. Lindzen, Harley Moody, Roger Pielke Sr., Jim Rust, Nicola Scafetta, Harrison Schmitt, and Adrian Vance. Any errors that remain are the sole responsibility of the author.

Why Seven Theories?

The theory of climate change that most people are familiar with is commonly called anthropogenic (man-made) global warming, or AGW for short. That theory holds that man-made greenhouse gases, primarily carbon dioxide (CO_2), are the predominant cause of the global warming that occurred during the past 50 years.

In the past few years, confidence in the AGW theory has declined dramatically. New research points to natural causes of the modern warming, and stabilizing (by some measures, falling) global temperatures have called attention to long-recognized shortcomings of the AGW theory. Tens of thousands of scientists have signed petitions expressing their dissent from the so-called "consensus" in favor of AGW. Opinion polls show a majority of the public in the U.S. and in other countries no longer believes human activity is causing global warming. Evidence of the decline of the AGW theory is presented in the postscript to this booklet.

The demise of the AGW theory makes this a good time to look at other theories of climate change put forward by prominent scientists but overlooked in the rush to judgment. This booklet identifies seven theories – AGW plus six others that do not claim man-made CO_2 is a major cause of climate change. Each theory is plausible and sheds light on some aspects of climate change that were hidden or obscured by too great a focus on the AGW theory.

In some respects these theories are not mutually exclusive: solar variability could be the sustaining force behind what I have called the "cloud formation and albedo" and "ocean currents" theories as well as being its own theory, though the mechanisms in each case differ slightly. Most physicists don't study biology or chemistry and so don't pay much attention to biological and chemical feedbacks. If they did, they would probably recognize that such processes play a bigger role in controlling climate than previously believed.

Deeper analysis also reveals that these theories are not all trying to answer the same questions or necessarily achieve predictive power. Trying to discern a human effect on climate is not the primary objective of biolo-

gists studying the effect of higher levels of CO_2 on plants or of physicists measuring the amount of energy leaving Earth's atmosphere. While they are "experts" on climate change, they are not part of the search for a "human fingerprint" on Earth's climate. Nor are they qualified to make predictions based on their narrow expertise, as Kesten Green at the University of South Australia and J. Scott Armstrong at the Wharton School of the University of Pennsylvania have tried to explain.

The six theories of climate change that do not involve man-made greenhouse gas emissions *are* incompatible, though, with the AGW theory. If evidence exists that negative feedbacks offset whatever warming is caused by man-made greenhouse gases, then the warming during the past 50 years could not be due to the burning of fossil fuels. Similarly, if solar variability explains most or all of the variation in temperatures in prehistoric as well as modern times, then there is no room for speculation about a large role for man-made CO_2.

Over time, the science of climatology will become somewhat more exact, based on examination of the historical record and newly assessed empirical evidence. It probably will not be illuminated much by mathematical models that cannot generate reliable forecasts of a system that even proponents of the anthropogenic global warming theory admit is naturally chaotic. We cannot adequately measure the enormous quantity of data necessary to feed the models, and we are not even sure which variables should be included. The uncertainty that pervades climate science today, as climate scientist Mike Hulme has written, is a function of the limits of science itself.

The object of this essay is not to say which of these seven theories is right or "best," but only to present them to the reader in a format that allows reflection and balanced consideration. Such dispassionate interest in the subject has been lacking in recent years, and the scientific debate has suffered for it.

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THEORY #1
Anthropogenic Global Warming

The first theory of climate change contends that human emissions of greenhouse gases, principally carbon dioxide (CO_2), methane, and nitrous oxide, are causing a catastrophic rise in global temperatures. The mechanism whereby this happens is called the enhanced greenhouse effect. We call this theory "anthropogenic global warming," or AGW for short.

Energy from the sun travels through space and reaches Earth. Earth's atmosphere is mostly transparent to the incoming sunlight, allowing it to reach the planet's surface where some of it is absorbed and some is reflected back as heat out into the atmosphere. Certain gases in the atmosphere, called "greenhouse gases," absorb the outgoing reflected or internal thermal radiation, resulting in Earth's atmosphere becoming warmer than it otherwise might be.

Water vapor is the major greenhouse gas, responsible for about 36 to 90 percent of the greenhouse effect, followed by CO_2 (<1 to 26 percent), methane (4 to 9 percent), and ozone (3 to 7 percent). (These estimates are the subject of much dispute, hence their wide ranges.) During the past century, human activities such as burning wood and fossil fuels and cutting down or burning forests are thought to have increased the concentration of CO_2 in the atmosphere by approximately 50 percent. Continued burning of fossil fuels and deforestation could double the amount of CO_2 in the atmosphere during the next 100 years, assuming natural "sinks" don't grow in pace with emissions.

Earth's climate also responds to several other types of external influences, such as variation in solar radiation and in the planet's orbit, but these "forcings," according to the proponents of AGW, cannot explain the rise in Earth's temperature over the past three decades. The forcing caused directly by man-made greenhouse gases is also small, but the AGW theory posits that positive feedbacks increase the effects of these gases between two- and four-fold. A small increase in temperature causes more evapo-

ration, which places more water vapor in the atmosphere, which causes more warming. Global warming may also lead to less ice and snow cover, which would lead to more exposed ground and open water, which on average are less reflective than snow and ice and thus absorb more solar radiation, which would cause more warming. Warming also might trigger the release of methane from frozen peat bogs and CO_2 from the oceans.

Backers of the AGW theory contend the ~0.7°C warming of the past century-and-a-half and ~0.5°C of the past 30 years is mostly or entirely attributable to man-made greenhouse gases. They dispute or disregard claims that some or perhaps all of that rise could be Earth's continuing recovery from the Little Ice Age (1400-1800). They use computer models based on physical principles, theories, and assumptions to predict that a doubling of CO_2 in the atmosphere would cause Earth's temperature to rise an additional 3.0°C (5.4°F) by 2100.

When these climate models are run "backwards" they tend to predict more warming than has actually occurred, but this, the theory's backers argue, is due to the cooling effects of aerosols and soot, which are also products of fossil fuel combustion. The models also predict more warming of a layer of the atmosphere (the troposphere) in the tropics than has been observed by satellite and radiosonde measurements, but AGW believers dispute the data showing that disparity.

Proponents of the AGW theory believe man-made CO_2 is responsible for floods, droughts, severe weather, crop failures, species extinctions, spread of diseases, ocean coral bleaching, famines, and literally hundreds of other catastrophes. All these disasters will become more frequent and more severe as temperatures continue to rise, they say. Nothing less than large and rapid reductions in human emissions will save the planet from these catastrophic events.

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THEORY #2
Bio-thermostat

The second theory of climate change holds that negative feedbacks from biological and chemical processes entirely or almost entirely offset whatever positive feedbacks might be caused by rising CO_2. These processes act as a "global bio-thermostat" keeping temperatures in equilibrium. The scientific literature contains evidence of at least eight such feedbacks, not counting cloud formation, which is treated as a separate theory in the next section of this booklet.

A. Carbon Sequestration

Increased carbon sequestration by plants is perhaps the best-known consequence of the rise in atmospheric CO_2. The productivity of most plants is enhanced because CO_2 is the primary raw material utilized by plants to construct their tissues. The more CO_2 there is in the air, the better plants grow and the more CO_2 they remove from the air and store in their leaves, branches, trunks, and roots, as well as in the soil beneath the plants – a suite of processes called "sequestration." Higher temperatures also tend to increase carbon sequestration rates.

Sequestration offsets some of the temperature-increasing power of higher levels of CO_2. How powerful is this negative feedback? The answer depends on the size, growth rate, and duration of the "sinks" in which carbon is stored. These variables in turn depend on constraints to plant growth (such as lack of water or nutrients in soil), the rate at which plant material decomposes, and even how higher CO_2 levels affect earthworms.

The latest research, by Wolfgang Knorr of the Department of Earth Sciences at Bristol University in England, indicates that sinks are growing in pace with man-made emissions, "having risen from about 2 billion tons a year in 1850 to 35 billion tons a year now," contradicting the assumptions made by the computer models used by advocates of the AGW theory. In addition, all carbon sinks have yet to be identified and new ones are being discovered every few years.

B. Carbonyl Sulfide

Carbonyl sulfide (COS) is a biologically produced sulfur gas emitted from soils. COS eventually makes its way into the stratosphere where it is transformed into sulfate aerosol particles, which reflect solar radiation back into space, producing a cooling effect on Earth's climate.

The rate at which COS is emitted increases as vegetation responds to the ongoing rise in the air's CO_2 content, meaning it is another negative feedback. The latest research indicates that the COS-induced cooling mechanism also operates at sea, as higher CO_2 and temperatures increase surface-water chlorophyll concentrations.

Ice core samples reveal that tropospheric COS concentration has risen approximately 30 percent since the 1600s, from a mean value of 373 parts per trillion (ppt) over the period 1616-1694 to about 485 ppt today. This is a sizeable increase, and only about one-fourth of it can be attributed to anthropogenic sources. While we need to learn more about this process, even state-of-the-art climate models neglect the possible effect of the COS cycle on climate. Until they take COS into account, these models are likely to forecast too much warming due to increases in CO_2.

C. Diffuse Light

A third negative feedback phenomenon is diffuse light. As higher levels of CO_2 promote greater plant productivity, plants emit greater amounts of gases converted into aerosols called "biosols." Biosols in turn act as cloud condensation nuclei, helping to create new clouds that reflect more incoming solar radiation back to space, thereby cooling the planet. More than that, they diffuse solar radiation close to the ground, reducing shade under plant canopies and thereby enhancing photosynthesis, which increases the amount of CO_2 plants absorb from the air and can sequester.

How significant is this negative feedback? A 2004 study published in *Geophysical Research Letters* found diffuse light increased "net CO_2 assimilation" by a broadleaf deciduous forest by between 30 percent and 50 percent. Once again, these effects are not adequately included in any computer model of Earth's climate system.

D. Iodocompounds

Iodinated compounds, or iodocompounds, are particles formed in sea air from iodine-containing vapors emitted by marine algae. These compounds, like the biosols previously discussed, help create clouds, which reduce the amount of solar radiation reaching the surface. Also like bio-

sols, the creation of iodocompounds is stimulated by rising CO_2 levels and warmer temperatures.

According to a study published in *Nature* in 2002, emissions of iodocompounds from marine biota "can increase by up to five times as a result of changes in environmental conditions associated with global change." A change of this magnitude "can lead to an increase in global radiative forcing similar in magnitude, but opposite in sign, to the forcing induced by greenhouse gases." In other words, this one biological process could offset all of the warming caused by rising CO_2 levels.

E. Dimethyl Sulfide

The amount of biologic dimethyl sulfide (DMS) emitted by the world's oceans is closely related to sea surface temperature: the higher the sea surface temperature, the greater the sea-to-air flux of DMS. DMS is a major source of cloud condensation nuclei, which generate clouds with greater cloud albedo. The greater the cloud albedo, the more incoming solar radiation gets blocked and reflected out to space.

How strong is this negative feedback? A study published in the *Journal of Geophysical Research* in 2000 found that a sea surface temperature increase of only 1°C was sufficient to increase the atmospheric DMS concentration by 50 percent. The warming typically predicted to accompany a doubling of the air's CO_2 content would increase the atmosphere's DMS concentration by a factor of three or more, providing what the study's authors call a "very important" negative feedback that could potentially offset the original impetus for warming. The effects of this process are not incorporated into today's state-of-the-art climate models.

F. Other Aerosols

There are many other kinds of aerosols, which scientists classify as marine biological, terrestrial biological, anthropogenic non-biological, and natural non-biological. Many of them are created, distributed, or destroyed in biological and chemical processes that tend to be counter-cyclical to the forcing of CO_2. In other words, when CO_2 is plentiful or when temperatures rise, these aerosols tend to increase in presence and reflect more solar radiation away from the planet's surface, causing it to cool.

The IPCC gives short shrift to the extensive scientific literature on aerosols, estimating their net effect to be just a small fraction of that of CO_2. However, a literature survey conducted by Idso and Singer in 2009 indicates the IPCC's estimate is far too low. Many studies suggest the cu-

mulative negative forcing of aerosols is large enough to completely offset the positive forcing due to rising atmospheric CO_2.

*

Some of these individual negative feedbacks may be sufficiently large to counter much of the effect of higher levels of CO_2 on global temperatures. Together, it is highly likely they constitute a "bio-thermostat" keeping Earth's temperature relatively stable. This would mean rising CO_2 would not cause catastrophic global warming.

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THEORY #3
Cloud Formation and Albedo

A third theory of climate change postulates that changes in the formation and albedo of clouds create negative feedbacks that cancel out all or nearly all of the warming effect of higher levels of CO_2. This theory is based largely on observational data reported by a series of researchers, rather than computer models as in the case of the AGW theory.

In 1999, Yogesh Sud, a NASA scientist, and his colleagues found that changes in cloud coverage in the tropics acted as a natural thermostat to keep sea surface temperature (SST) between approximately 28°C and 30°C. Their analysis suggested that as SSTs rise, air at the base of the clouds is charged with the moist static energy needed for clouds to reach the upper troposphere, at which point the cloud cover reduces the amount of solar radiation received at the surface of the sea and cool and dry downdrafts promote ocean surface cooling.

This "thermostat-like control," as Sud *et al.* described it, tends "to ventilate the tropical ocean efficiently and help contain the SST between 28°-30°C." The phenomenon also would be expected to prevent SSTs from rising any higher in response to enhanced CO_2-induced radiative forcing.

In 2001, Richard Lindzen, a professor of meteorology at Massachusetts Institute of Technology (MIT), and colleagues examined upper-level cloudiness data and SST data and discovered a strong inverse relationship between upper-level cloud area and the mean SST of cloudy regions of the eastern part of the western Pacific. The area of cirrus cloud coverage decreased about 22 percent for each 1°C increase in SST. Lindzen *et al.* wrote, "the cloudy-moist region appears to act as an infrared adaptive iris that opens up and closes down the regions free of upper-level clouds, which more effectively permit infrared cooling, in such a manner as to resist changes in tropical surface temperature." The sensitivity of this negative feedback was calculated by Lindzen *et al.* to be so substantial that it would "more than cancel all the positive feedbacks in the more sensitive current climate models."

In 2008, climatologist and former NASA scientist Roy Spencer and colleagues used new satellite data to support Lindzen's "adaptive iris" thesis, finding "the net ... radiative effect of clouds during the evolution of the composite ISO [tropical intra-seasonal oscillations] is to cool the ocean-atmosphere system during its tropospheric warm phase, and to warm it during its cool phase."

In 2009, Lindzen and coauthor Yong-Sang Choi found "for the entire tropics, the observed outgoing radiation fluxes increase with the increase in sea surface temperatures (SSTs). The observed behavior of radiation fluxes implies negative feedback processes associated with relatively low climate sensitivity. This is the opposite of the behavior of 11 atmospheric models forced by the same SSTs."

In 2010, Lindzen and Choi responded to critics with a new study accounting for orbital drift by ERBE satellites and other data issues. They once again found negative feedback by clouds in the tropics, which "implies that the models are exaggerating climate sensitivity." If they are right, clouds act as a negative feedback to the warming that would otherwise be caused by man-made CO_2 emissions, eliminating any net warming.

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THEORY #4
Human Forcings Besides Greenhouse Gases

A fourth theory of climate change holds that mankind's greatest influence on climate is not its greenhouse gas emissions, but its transformation of Earth's surface by clearing forests, irrigating deserts, and building cities. Roger Pielke, Sr., a climatologist at the University of Colorado – Boulder, phrases the theory as follows:

> Although the natural causes of climate variations and changes are undoubtedly important, the human influences are significant and involve a diverse range of first-order climate forcings, including, but not limited to, the human input of carbon dioxide (CO_2).

Short descriptions of some of these "human forcings" other than greenhouse gases (not all of them reported by Pielke) follow.

Urban Heat Islands

Cities tend to be warmer than suburbs, and suburbs warmer than rural areas, because they have greater concentrations of energy-producing machines and vehicles and large amounts of concrete, asphalt, and other building and road materials that absorb solar energy and then re-emit thermal energy. These "urban heat island" effects have been documented by many authors. De Laat *et al.*, in a 2004 study published in *Geophysical Research Letters*, concluded that "the 'real' global mean surface temperature trend is very likely to be considerably smaller than the temperature trend in the CRU [Hadley Center/Climatic Research Unit] data." Advocates of the AGW theory falsely attribute higher temperatures caused by urban heat islands to rising atmospheric CO_2 levels.

Aerosols and ozone

Anthropogenic aerosols and ozone have shorter lifetimes than greenhouse gases, and therefore their concentrations are higher in source regions and downwind. Pielke and colleagues estimate the effect of human aerosols on the gradient of radiative heating on regional scales "is on the order of 60 times that of the well-mixed greenhouse gases." With many surface-based temperature stations located in urban or near-urban areas, it is likely they are registering the warming effects of these aerosols and ozone, not CO_2.

Deforestation

Removing trees by burning, a common practice in developing countries, releases CO_2 into the atmosphere and prevents forests from sequestering carbon in the future. The pasture or crop land that replaces the forest lacks the shade created by a forest canopy and tends to be warmer. The IPCC has estimated that between one-quarter and one-third of anthropogenic CO_2 emissions are due to deforestation, not the burning of fossil fuels, though this estimate has been challenged as being too high.

Coastal development

Anthropogenic activities in coastal areas such as logging, agriculture, construction, mining, drilling, dredging, and tourism all can increase or (more rarely) decrease surface temperatures of nearby bodies of water. For example, storm runoff from city streets following heavy rains can result in seawater dilution and temperature increases. Development can produce sediment that reduces streamflow and damages coral reefs by reducing the penetration of sunlight or by direct deposit on the coral, causing damage mistakenly attributed to global warming.

Jet contrails

Anyone living in or near a large city knows that jets often leave trails behind them, called contrails (short for "condensation trails"). Composed of water vapor, they precipitate the creation of low clouds that have a net warming effect. According to a 2006 study published in the *International Journal of Climatology*, contrails in the U.S. "may cause a net warming of the surface rivaling that of greenhouse gases" and "in certain regions, contrails already may contribute as much as the present anthropogenic CO_2 forcing on climate."

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Several of these "human forcings" have local and regional effects on climate equal to or even exceeding that of anthropogenic greenhouse gas emissions. This leaves little or no warming left to be explained by the AGW theory. Unfortunately, as Roger Pielke concludes, the IPCC in 2007 "did not sufficiently acknowledge the importance of these other human climate forcings in altering regional and global climate and their effects on predictability at the regional scale. It also placed too much emphasis on average global forcing from a limited set of human climate forcings."

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THEORY #5
Ocean Currents

The fifth theory of climate change contends that global temperature variations over the past century-and-a-half, and particularly the past 30 years, were due to the slow-down of the ocean's Thermohaline Circulation (THC). William "Bill" Gray, professor emeritus of atmospheric science at Colorado State University and head of the Tropical Meteorology Project at the university's Department of Atmospheric Sciences, is the leading proponent of this theory. The following summary is based on several of his papers and presentations.

Ocean water is constantly transferred from the surface mixed layer to the interior ocean through a process called ventilation. The ocean fully ventilates itself every 1,000 to 2,000 years through a polar region (Atlantic and Antarctic) deep ocean subsidence of cold-saline water and a compensating upwelling of warmer less saline water in the tropics. This deep ocean circulation, called the Meridional Overturning Circulation (MOC), has two parts, the primary Atlantic Thermohaline Circulation (THC) and the secondary Surrounding Antarctica Subsidence (SAS).

Paleo-proxy data and meteorological observations show there have been decadal to multi-century scale variations in the strength of the THC over the past thousand years. When the THC circulation is stronger than normal the earth-system experiences a slightly higher level of evaporation–precipitation (~2 percent). When the THC is weaker than normal, as it is about half the time, global rainfall and surface evaporation are reduced about 2 percent.

It requires extra energy (29 W/m^2) from the ocean surface to evaporate or turn 1 mm of liquid water into water vapor. This energy depletion during periods of high Atlantic THC conditions acts together with the enhancement of the upwelling of deep ocean cold water into the tropical ocean upper level mixed region to bring about additional upper-level ocean energy depletion and finally, with a lag of 5 to 10 years, reduced ocean surface temperatures.

When the THC is relatively weak (as it was during the periods 1910-1940 and 1970-1994), the earth-system typically has less net evaporation cooling and less deep ocean upwelling of cold water. At these times, energy accumulates in the ocean's upper mixed layer and over a period of a decade or two the global ocean begins to warm.

The average strength of the Atlantic THC varies about one to two Sverdrups (a unit of measure of volume transport, about 264 million U.S. gallons per second) from its long-term average of about 14 Sverdrups. The average THC appears to continuously deplete energy from the ocean at a rate of about 3 W/m^2. This long-period energy loss is balanced by a near-constant extra solar energy gain. When the THC is stronger than average, this upwelling of colder deeper water into the tropical mixed layer brings a general energy depletion of the upper 50 to 100 meters of mixed tropical ocean upper layer of about 4 W/m^2. When the THC is weaker than average, the energy depletion drops to about 2 W/m^2. These ocean energy depletions/accumulations acting over periods of 20-30 years can lead to significant sea surface temperature differences.

Besides this deep ocean global THC circulation, there are also up-and-down-welling ocean areas that are a product of the ocean's horizontal surface wind configurations. These "Ekman" patterns can also contribute to local and global temperature change depending on where they occur.

These combined THC and Ekman changes have no known association with anthropogenic greenhouse gas increases. A slowdown of the global THC circulation occurs due to Atlantic Ocean salinity decreases. This typically brings about a few decades of reduction in Antarctic deep-water formation.

How powerful is the effect on climate of these natural changes in ocean currents compared to estimates of the effect of man-made greenhouse gases? According to Gray, pre-industrial amounts of CO_2 have been estimated at 290 ppm. The energy gain from a doubling of CO_2 to 580 ppm with all other processes held fixed has been calculated to be 3.7 W/m^2. Mauna Loa Observatory measurements of CO_2 in ppm were about 390 in 2010. The change in CO_2 energy forcing from pre-industrial conditions of 290 ppm to today's value of about 390 gives an idealized outgoing longwave radiation (OLR) blocking of energy to space of 100/290 x 3.7 = 1.3 W/m^2. This is *less* than the 2 W/m^2 energy alteration that occurs from the ordinary alteration of the thermohaline circulation.

According to Gray, changes of the Meridional Overturning Circulation (MOC) since 1995 led to the cessation of global warm-

ing since the 1998-2001 period and triggered the beginning of a weak global cooling trend since 2001. Gray projects this weak cooling to continue for the next couple of decades. "I expect to live to see the start of a global cooling pattern and the discrediting of most of the anthropogenic warming arguments," he wrote in 2009. "The world has more serious problems to worry about."

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THEORY #6
Planetary Motion

The sixth theory of climate change contends that most or all of the warming of the latter part of the twentieth century can be explained by natural gravitational and magnetic oscillations of the solar system induced by the planet's movement through space. These oscillations modulate solar variations and/or other extraterrestrial influences of Earth, which then drive climate change.

An extraterrestrial influence on climate on a multi-millennial timescale associated with planetary motion was first suggested by a Serbian astrophysicist, Milutin Milankovitch, and published in 1941. More recent discoveries have enabled scientists to accurately measure these effects on climate.

Earth's orbit around the sun takes the form of an ellipse, not a circle, with the planet passing farther away from the sun at one end of the orbit than at the other end. The closest approach of the planet to the sun is called "perihelion" and the farthest is called "aphelion." Perihelion now occurs in January, making northern hemisphere winters slightly milder. The change in timing of perihelion is known as the precession of the equinoxes, and it occurs every 22,000 years.

The shape or "eccentricity" of Earth's orbit also varies on cycles of 100,000 and 400,000 years due to the tug of other planets, specifically Jupiter and Saturn, on Earth. It shifts from a short broad ellipse that keeps Earth closer to the sun, to a long flat ellipse that allows it to move farther from the sun and back again. Earth also spins around an axis that tilts lower and then higher during a 41,000-year cycle. More "tilt" roughly means warmer northern hemisphere summers and colder winters; less "tilt" means cooler summers and milder winters.

The coincidence of these cycles is known to lead, with the help of positive climatic feedbacks such as water vapor, to the cooling and warming periods we recognize from historical data as Ice Ages and Interglacial

Periods. Scientists now know that the precession of Earth's orbit means that about 11,000 years from now, the northern midwinter will fall in July instead of January, and the continental glaciers may return.

Could variation in the planet's movement through space account for climate change on a decadal scale as well as a millennial scale? Nicola Scafetta, a physicist at Duke University, suggests two possible mechanisms may be at work: 1) the varying tidal gravitational and magnetic forces of the planets on the sun, in particular of Jupiter and Saturn, modulate solar activity and then solar variations modulate the terrestrial climate; and 2) the varying gravitational and magnetic fields generated by the movement of Jupiter and Saturn modulate some terrestrial orbital parameters, for example the spinning of Earth better known as the "length of the day" (LOD), which then drives the ocean oscillations and, consequently, the climate.

Scafetta tested this theory using the sun's movement relative to the center of mass of the solar system (called the "barycenter") as a proxy for all the known and unknown cycles involving natural oscillations of the solar system. He found "all alternating periods of warming and cooling since 1860 are very well reconstructed by the model." He goes on to use the model to predict future climate change:

> The forecasts indicate that climate may cool until the 2030s. At the end of the 21st century relative to today's temperature the climate may warm at most by 1°C if the quadratic fit forecast holds. The model suggests that climate is modulated by large 60, 30, 20 and 10 year natural cycles that combined have a max-min amplitude of about 0.3-0.4°C on the 60 year cycle. This explains most of the 1910-1945 warming of about 0.40-0.45°C and implies that about 60-70% of the observed warming from 1975 to 2002 was part of this natural climate cycle during its warm phase.

The climate models used by proponents of the AGW theory are notoriously unable to recreate past temperature variation without extensive "tweaking" of the models to fit the data. Scafetta's model, without any similar trickery, explains most of the warming of the twentieth century. The difference between Scafetta's climate forecast and the IPCC's could not be more striking: Scafetta forecasts cooling for the next two decades, while the IPCC forecasts catastrophic warming.

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THEORY #7
Solar Variability

The seventh theory of climate change is that solar variability accounts for most or all of the warming in the late twentieth century and will dominate climate in the twenty-first century regardless of man-made greenhouse gas emissions.

Changes in the brightness of the sun are caused by sunspots – bursts of energetic particles and radiation – that vary in frequency in cycles of roughly 11, 87, and 210 years. These cycles cause changes in the amount of electromagnetic radiation – also called "solar wind" – that reaches Earth and its atmosphere, which in turn affects Earth's climate. Most proponents of the theory that solar variability drives changes in Earth's climate believe positive feedback occurs either by a process involving the influence of the solar wind on cosmic rays, which affects cloud formation, or on the oceans' thermohaline circulation (THC), which affects sea surface temperatures and wind patterns.

Evidence of a Solar Effect

According to the IPCC, "changes in solar irradiance since 1750 are estimated to cause a radiative forcing of +0.12 [+0.06 to +0.30] W/m^2," which is an order of magnitude smaller than the IPCC's estimated net anthropogenic forcing of +1.66 W/m^2 from CO_2 over the same time period. However, many scientists believe the IPCC got it backwards, that proxy data from ice cores, drift ice debris, and other sources reveal that the sun's influence was ten times as important as CO_2 in influencing global temperatures in the past.

Paleo-oceanographer Gerard Bond and colleagues at Columbia University's Lamont-Doherty Earth Observatory, in research published in *Science* in 2001, found changes in global temperatures occurred in cycles of roughly 1,500 years over the past 12,000 years,

with virtually every cooling period coinciding with a solar minimum. Four years later, writing in *Nature,* a team of researchers from the Heidelberg Academy of Sciences, the University of Heidelberg, the Potsdam Institute for Climate Impact Research, and the Alfred Wegener Institute for Polar and Marine Research demonstrated that the known 210-year and 87-year cycles of the sun could combine to form a 1,470-year cycle.

Craig Loehle, principal scientist at the National Council for Air and Stream Improvement, in 2004 used a pair of 3,000-year proxy climate records to demonstrate a similar connection. Willie Soon, an astrophysicist at the Harvard-Smithsonian Center for Astrophysics, and Nicola Scafetta, a physicist at Duke University, have similarly documented close correlations using different temperature records and measures of solar radiation.

Correlation, even repeatedly demonstrated, doesn't prove causation. Around 2000, several scientists working independently made discoveries that demonstrated plausible mechanisms linking variation in solar radiation to decadal changes in global temperature.

Solar Wind Modulation of Cosmic Rays

Henrik Svensmark and Eigil Friis-Christensen, astrophysicists at the Danish National Space Center, in a seminal scientific paper published in 1997, proposed that electrons released to the atmosphere by galactic cosmic rays stimulate the formation of ultra-small clusters of sulfuric acid and water molecules that constitute the building blocks of cloud condensation nuclei. During periods of greater solar magnetic activity, the stronger solar wind blocks some of the cosmic rays from penetrating the lower atmosphere, resulting in fewer cloud condensation nuclei being produced. The result is the creation of fewer and less reflective low-level clouds, resulting in increasing near-surface air temperatures and global warming.

How powerful is this solar wind-cosmic ray interaction? A 2002 study published in *Science* found the intensity of cosmic rays varies by about 15 percent over a solar cycle, which in turn is associated with variation in low cloud amount over a solar cycle by about 1.7 percent. This change in cloud cover corresponds to a change in the planet's radiation budget of about one watt per square meter (1 W/m^2). This change, the authors wrote, "is highly significant when compared ... with the estimated radiative forcing of 1.4 W/m^2 from anthropogenic CO_2 emissions."

Two other scientists, Jan Veizer, Distinguished University Professor (emeritus) of Earth Sciences at the University of Ottawa, and Nir J. Shaviv of the Racah Institute of Physics at The Hebrew University of Jerusalem,

found in 2003 that between two-thirds and three-fourths of the variance in Earth's temperature over the past 500 million years may be attributable to cosmic ray flux. Once this is taken into account, they say, a doubling of the air's CO_2 concentration could account for only about a 0.5°C increase in global temperature, about the same increase found by many other scientists who dispute the AGW theory.

Solar-Arctic Connection

A second group of scientists believes small changes in solar radiation entering Earth's atmosphere are amplified by positive feedbacks involving the transfer of energy between equator and Arctic via wind patterns and oceans. Bond *et al.* envisioned solar variability provoking changes in North Atlantic deep water formation that alter the thermohaline circulation of the global ocean.

A new paper by Soon demonstrates the plausibility of a three-part mechanism whereby variation in total solar irradiance (TSI) affects Arctic temperatures by modulating the thermohaline circulation (THC), the Inter-Tropical Convergence Zone (ITCZ) rainbelt and tropical Atlantic ocean conditions, and the intensity of the wind-driven subtropical and subpolar gyre circulation, the ring-like system of ocean currents rotating clockwise in the Northern Hemisphere and counterclockwise in the Southern Hemisphere. Soon tested this "TSI-Arctic thermal-salinity-cryospheric coupling mechanism" by showing the predicted 5-to-20-year delayed effects of TSI variability on the peak Meridional Overturning Circulation (MOC) flow rate centered near 30°-35°N, and sea surface temperature (SST) for the tropical Atlantic. He found very close fits on multidecadal to centennial timescales.

Soon concludes, "the proposed solar-Arctic connection chains ... have good empirical support, and this mechanism appears to explain the operation of coupled air-ocean-ice responses over broad areas connecting the Arctic and North Atlantic to other locations on multidecadal to centennial timescales." He cautions, though, that his theory "should be viewed as a step forward in the long quest" to understand how the full weather-climate continuum operates and the role of solar irradiance forcing.

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Postscript

Scientists have long known that many factors influence Earth's climate, including variations in the sun's brightness and magnetic field strength and the planet's orbit, the planet's movement through the galaxy, and changes in land use. Why have these and other natural explanations of climate change been ignored while one theory, anthropogenic global warming (AGW), has been treated as the only credible theory?

Beginning in the 1970s, the rising concentration of carbon dioxide (CO_2) in the atmosphere began to catch the attention of scientists and the general public. At that time, some scientists thought industrial activities that cause rising levels of CO_2 and aerosol particles explained the cooling trend that had begun in the 1940s. Later, some of those same scientists would blame CO_2 for the global *warming* period that began in the 1980s and ended around 2000.

Intergovernmental Panel on Climate Change

A major reason for the ascendence of the AGW theory was its endorsement by an agency of the United Nations, the Intergovernmental Panel on Climate Change (IPCC). The IPCC's stated mission is not to discover what accounts for climate change, but to assess "the risk of human-induced climate change." Consequently, there is almost no discussion in its lengthy reports of other theories of climate change. Policymakers and journalists took this to mean the AGW theory was the only credible theory of climate change, and the IPCC's sponsors and spokespersons had no incentive to correct the mistake.

The IPCC, as its name suggests, is a political rather than a scientific organization. Its key personnel and even lead authors are often environmental activists appointed by governments. While the IPCC claims to represent the views of "2,500 leading climate scientists," this number includes scientists whose work is only cited in the reports, not who actively contributed or participated in peer review. It does not reveal how many scientists endorse any IPCC report.

IPCC reports are edited and rewritten by nonscientists to fulfill the political objectives of the IPCC's members *after* the scientists who help write them have finished their work. The reports contain much science, but a small group of political insiders pick what science to include and what to leave out.

Other Voices in the Debate

Scientific dissent to the IPCC's exclusive advocacy of the AGW theory was present almost from the start. For example, Frederick Seitz, Richard Lindzen, and S. Fred Singer, all prominent scientists, appeared in the popular press calling attention to the IPCC's dismissal of natural causes of climate change. Books by Singer, Robert Balling, Christopher Essex, Robert Jastrow, Patrick Michaels, Roy Spencer, and other leading scientists described the shortcomings of the AGW theory and pointed to other, more plausible theories.

In 2007, a petition signed by 31,478 American scientists, including 9,029 with Ph.D.s, read in part, "there is no convincing scientific evidence that human release of carbon dioxide, methane, or other greenhouse gases is causing or will, in the foreseeable future, cause catastrophic heating of the Earth's atmosphere and disruption of the Earth's climate." (The petition was first circulated in 1999; the majority of the current listed signatories signed or re-signed the petition after October 2007. The petition can be viewed online at www.petitionproject.org.)

Climategate and Other Scandals

In November 2009, emails and other scientific documents were mysteriously "leaked" from the Climatic Research Unit at the University of East Anglia in Britain. The emails revealed deliberate efforts by some of the most prominent advocates of the AGW theory to suppress scientific debate by keeping opposing views out of peer-reviewed journals and withholding data from other researchers. The scientific documents revealed that temperature data relied upon by the IPCC to document the warming trend in the late twentieth and early twenty-first centuries were lost, destroyed, or in disarray and unreliable.

In December 2009, international negotiations in Copenhagen for a successor to the Kyoto Protocol collapsed, leaving the world with no agreed-upon path for agreement on an international treaty on greenhouse gas emissions after 2012. In January 2010, a bill to impose restrictions on greenhouse gas emissions died in the U.S. Senate.

In early 2010, new revelations appeared of errors and fraud in the IPCC's Fourth Assessment Report. Manipulation of temperature data in

the U.S., Russia, Canada, and Australia was exposed, along with false claims relating to the rate of melting of Himalayan glaciers, potential loss of Amazonian rainforests, and increases in damage due to severe weather. Most of these errors, and more, already had been documented by the authors mentioned previously, but now the media (at least in England, Canada, India, and other parts of the world) were paying attention and reporting them as scandals.

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This brief history helps explain why relatively few people realize that the AGW theory, which blames human activity for climate change, is not the only or even the most credible theory of climate change. It just happened to be the one that best advanced the agendas of the individuals and interest groups who so successfully promoted it.

At least seven theories of climate change enjoy some support in the scientific community. With the AGW theory now in disrepute, it is a good time to review the other six and recognize what they each contribute to our understanding of what causes Earth's climate to change.

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SEVEN THEORIES OF CLIMATE CHANGE

"At least seven theories of climate change enjoy some support in the scientific community. With the anthropogenic global warming theory now in disrepute, it is a good time to review the other six …"

This booklet identifies seven theories, anthropogenic global warming (AGW) plus six others that do not claim man-made emissions are a major cause of climate change. Each theory is plausible and sheds light on some aspects of climate change that were hidden or obscured by too great a focus on the AGW theory.

The six alternative theories are:

- **Bio-thermostat** — rising temperatures and levels of carbon dioxide (CO_2) in the atmosphere trigger biological and chemical responses that have a cooling effect, like a natural thermostat.

- **Cloud formation and albedo** — changes in the formation and albedo of clouds create negative feedbacks that cancel out all or nearly all of the warming effect of higher levels of CO_2.

- **Human forcings besides greenhouse gases** — mankind's greatest influence on climate is not its greenhouse gas emissions, but its transformation of Earth's surface by clearing forests, irrigating deserts, and building cities.

- **Ocean currents** — global temperature variations over the past century-and-a-half and particularly the past 30 years were due to the slow-down of the ocean's Thermohaline Circulation (THC).

- **Planetary motion** — natural gravitational and magnetic oscillations of the solar system induced by the planet's movement through space drive climate change.

- **Solar variability** — changes in the brightness of the sun cause changes in cloud formation, ocean currents, and wind that cause climate to change.

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The Heartland Institute is a nonprofit, nonpartisan research organization based in Chicago. Founded in 1984, it is devoted to discovering, developing, and promoting free-market solutions to social and economic problems. It is supported by the voluntary contributions of approximately 1,800 supporters. For more information, please visit our Web site at www.heartland.org or call 312/377-4000.

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