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Global warming

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Global warming

What is the greenhouse effect, and is it affecting our climate?

The greenhouse effect is unquestionably real, and is essential for life on Earth. It is the result of heat absorption by certain gases in the atmosphere (called greenhouse gases because they trap heat) and re-radiation downward of a part of that heat. Water vapor is the most important greenhouse gas, followed by carbon dioxide and other trace gases. Without a natural greenhouse effect, the temperature of the Earth would be about zero degrees F (-18°C) instead of its present 57°F (14°C). However, the concern is not with the fact that we have a greenhouse effect, but it is with the question regarding whether human activities are leading to an enhancement of the greenhouse effect.

Are greenhouse gases increasing?

Human activity has been increasing the concentration of greenhouse gases in the atmosphere (mostly carbon dioxide from combustion of coal, oil, and gas; plus a few other trace gases). There is no scientific debate on this point. Pre-industrial levels of carbon dioxide (prior to the start of the Industrial Revolution) were about 280 parts per million by volume (ppmv), and current levels are about 370 ppmv. According to the IPCC "business as usual" scenario of

carbon dioxide increase (IS92a) in the 21st century, we would expect to see a doubling of carbon dioxide over pre-industrial levels around the year 2065.

Is the climate warming?

Global surface temperatures have increased about 0.6°C (plus or minus 0.2°C) since the late-19th century, and about one half degree F (0.2 to 0.3°C) over the past 25 years (the period with the most credible data). The warming has not been globally uniform. Some areas (including parts of the southeastern U.S.) have cooled. The recent warmth has been greatest over N. America and Eurasia between 40 and 70°N. Warming, assisted by the record El Nico of 1997-1998, has continued right up to the present.

Linear trends can vary greatly depending on the period over which they are computed. Temperature trends in the lower troposphere (between about 2,500 and 18,000 ft.) from 1979 to the present, the period for which Satellite Microwave Sounding Unit data exist, are small and may be unrepresentative of longer term trends and trends closer to the surface. Furthermore, there are small unresolved differences between radiosonde and satellite observations of tropospheric temperatures, though both data sources show slight warming trends. If one calculates trends beginning with

the commencement of radiosonde data in the 1950s, there is a slight greater warming in the record due to increases in the 1970s. There are statistical and physical reasons (e.g., short record lengths, the transient differential effects of volcanic activity and El Nico, and boundary layer effects) for expecting differences between recent trends in surface and lower tropospheric temperatures, but the exact causes for the differences are still under investigation (see National Research Council report "Reconciling Observations of Global Temperature Change").

An enhanced greenhouse effect is expected to cause cooling in higher parts of the atmosphere because the increased "blanketing" effect in the lower atmosphere holds in more heat. Cooling of the lower stratosphere (about 30-35,000ft.) since 1979 is shown by both satellite Microwave Sounding Unit and radiosonde data, but is larger in the radiosonde data.

There has been a general, but not global, tendency toward reduced diurnal temperature range (the difference between high and low daily temperatures) over about 50% of the global land mass since the middle of the 20th century. Cloud cover has increased in many of the areas with reduced diurnal temperature range.

Relatively cool surface and tropospheric temperatures, and a relatively warmer lower stratosphere, were observed in 1992 and 1993,

following the 1991 eruption of Mt. Pinatubo. The warming reappeared in 1994. A dramatic global warming, at least partly associated with the record El Nico, took place in 1998. This warming episode is reflected from the surface to the top of the troposphere.

Indirect indicators of warming such as borehole temperatures, snow cover, and glacier recession data, are in substantial agreement with the more direct indicators of recent warmth.

Arctic sea ice has decreased since 1973, when satellite measurements began but Antarctic sea ice may have increased slightly.

Are El Ninos related to Global Warming?

El Ninos are not caused by global warming. Clear evidence exists from a variety of sources (including archaeological studies) that El Ninos have been present for hundreds, and some indicators suggest maybe millions, of years. However, it has been hypothesized that warmer global sea surface temperatures can enhance the El Nico phenomenon, and it is also true that El Ninos have been more frequent and intense in recent decades.Recent climate model results that simulate the 21st century with increased greenhouse gases (using the IPCC IS92a greenhouse gas increase scenario) suggest that El Nicos are likely to become more common in the future.

Is the hydrological cycle (evaporation and precipitation) changing?

There has probably been only a small (1%) increase in global precipitation over land during the 20th century. Precipitation has increased over land in high latitudes of the northern hemisphere, especially during the cold season, concomitant with temperature increases. A step-like decrease of precipitation occurred after the 1960s between the equator and about 35 degrees latitude, from Africa to Indonesia, as temperatures increased. These changes are consistent with observed changes in streamflow, lake levels, and soil moisture (where data are available and have been analyzed).

Northern Hemisphere snow cover extent has consistently remained below average since 1987.

Pan evaporation, a measure of potential evaporation, has decreased since 1951 over much of the former Soviet Union and the U.S. However, actual evaporation, which is dependant on available water, may have increased. Evaporation appears to have increased over the tropical oceans (although not everywhere). The evidence suggests an increase of atmospheric water vapor in the tropics, at least since 1973.

In general, cloud amount has increased both over land and ocean in recent decades. Over the

ocean, increases in convective and middle- and high-level clouds have been reported.

Is the atmospheric/oceanic circulation changing?

A rather abrupt change in the El Nico - Southern Oscillation behavior occurred around 1976/77 and the new regime has persisted. There have been relatively more frequent El Nico episodes. This behavior is highly unusual in the last 120 years (the period of instrumental record). Changes in precipitation over the tropical Pacific are related to this change in the El Nico - Southern Oscillation, which has also affected the pattern and magnitude of surface temperatures.

Is the climate becoming more variable or extreme?

On a global scale there is little evidence of sustained trends in climate variability or extremes. This perhaps reflects inadequate data and a dearth of analyses. However, on regional scales, there is clear evidence of changes in variability or extremes.

In areas where a drought usually accompanies an El Nico, droughts have been more frequent in recent years. Other than these areas and the few areas with longer term trends to lower rainfall

(e.g., the Sahel), little evidence is available of changes in drought frequency or intensity.

In some areas there is evidence of increases in the intensity of extreme rainfall events, but no clear global pattern has emerged. Despite the occurrence in recent years of several regional-scale extreme floods there is no evidence of widespread changes in flood frequency. This may reflect the dearth of studies, definition problems, and/or difficulties in distinguishing the results of land use changes from meteorological effects.

There is some evidence of recent (since 1988) increases in extreme extratropical cyclones over the North Atlantic. Intense tropical cyclone activity in the Atlantic appears to have decreased over the past few decades. Elsewhere, changes in observing systems confound the detection of trends in the intensity or frequency of extreme synoptic systems.

There has been a clear trend to fewer extremely low minimum temperatures in several widely-separated areas in recent decades. Widespread significant changes in extreme high temperature events have not been observed.

There is some indication of a decrease in day-to-day temperature variability in recent decades.

How important are these changes in a longer-term context?

For the Northern Hemisphere summer temperature, recent decades appear to be the warmest since at least about 1000AD, and the warming since the late 19th century is unprecedented over the last 1000 years. Older data are insufficient to provide reliable hemispheric temperature estimates. Ice core data suggest that the 20th century has been warm in many parts of the globe, but also that the significance of the warming varies geographically, when viewed in the context of climate variations of the last millennium.

Large and rapid climatic changes affecting the atmospheric and oceanic circulation and temperature, and the hydrological cycle, occurred during the last ice age and during the transition towards the present Holocene period (which began about 10,000 years ago). Based on the incomplete evidence available, the projected change of 3 to 7°F (1.5 - 4°C) over the next century would be unprecedented in comparison with the best available records from the last several thousand years.

Is sea level rising?

Global mean sea level has been rising at an average rate of 1 to 2 mm/year over the past 100 years, which is significantly larger than the rate averaged over the last thousand years. Projected increase for the 21st century is about 0.5 meter, but estimates range widely.

Can the observed changes be explained by natural variability, including changes in solar output?

Some changes, particularly part of the pre-1960 temperature record, show some relationship with solar output, but the more recent warm era is not well correlated. The exact magnitude of purely natural global mean temperature variance is not known precisely, but model experiments excluding solar variation indicate that it is likely less than the variability observed during this century.

Global Warming or Global Cooling the Threat for the Future?

Has the climate of the United States changed significantly during the century that is about to end? In what ways and by how much? Have national trends emerged that agree--or perhaps disagree--with what is expected from projections of

global greenhouse warming? These are questions addressed in a report entitled "Trends in U.S. Climate during the Twentieth Century," by Thomas R. Karl, Richard W. Knight, David R. Easterling, Robert G. Quayle who serve on the scientific staff of the National Oceanic and Atmospheric Administration's National Climatic Data Center (NCDC), in Asheville, North Carolina. Thomas "The challenge to the climatologist is to separate any meaningful signals from ever-present noise, and to discern, if possible, whether there is indeed at work the sometimes slow and subtle hand of significant change. The second task, which is even harder, is to identify, unequivocally, the cause," according to the scientists was the focus of their study.

"Before such questions can be answered, we need to remind ourselves that 'climate', as it is defined for a specific region and time, includes more than the simple average of weather conditions. Either random events or long-term persistent change, or more often combinations of them, can bring about significant swings in a variety of climate indicators from one time period to the next. Examples include a year dominated by severe drought and the next excessively wet; a series of bitterly cold winters followed by winters more mild; one scorching summer preceded by a summer pleasantly warm; years with numerous severe storms followed by years with few severe storms. The temptation at each time and place is often to attribute any of

these temporal and sometimes local variations to a wider and more pervasive change in climate..."

GREENHOUSE WARMING

In their assessment they noted that the so-called "greenhouse" gases "have all been markedly increasing in amount since about the time of the industrial revolution, that began in earnest some 150 years ago. The largest and best-known contributor is carbon dioxide, originating principally from the burning of wood and coal and petroleum derivatives. However, other climatic trends include "changes in the composition of the atmosphere in ways that act to cool the surface temperature. This includes the anthropogenic decrease of stratospheric ozone, and an increase in anthropogenic microscopic sulfate particles, often readily apparent during the warm season as smog. The effect of these additional atmospheric constituents on global climate is less certain than that of the better known greenhouse gases, but models suggest that in some areas they may have already acted to significantly retard greenhouse warming. It is important to note, however, that the global-scale warming predicted in climate modeling experiments from future greenhouse gas increases is substantially larger on a global average than the regional cooling expected from these other sources.

Measurements of past and current levels of carbon dioxide and other greenhouse gases indicate that we should have already increased the global

greenhouse effect by man-made, or anthropogenic additions, by nearly 40% in the last 150 years. If these changes were the only process of importance, then the same mathematical climate models suggest that the average global surface temperature should have risen by about 1° C during this time. Available climate data suggest that the mean global temperature has indeed risen, but unsteadily and by only about half that amount.

"Confounding any search for anthropogenic effects are the natural changes and variations of climate that will constantly add to or subtract from the expected signal. Examples include changes in upper atmospheric steering winds (commonly known as the jet stream) due to ocean-atmosphere interactions; changes in the circulation of the ocean that can influence air temperatures; effects of major volcanic eruptions; feedbacks from changes in the land surface, as in soil moisture, snow cover, and plant cover; and changes in the energy received from the Sun.

PRECIPITATION AND DROUGHT

Another factor in the climatic equation is precipitation and drought. Studies indicate that, "since about 1970 precipitation has tended to remain above the twentieth century mean, averaging about 5% higher than in the previous 70 years. Such an increase hints at a change in climate. Statistical analysis suggests that the change is unusual, but there is still about a 10%

chance that such a change could arise from a stable or quasi-stationary climate without any real long-term changes."

TEMPERATURE

While during the 1930's there was a sharp rise in temperature, there was a modest cooling trend from the 1950's to the 1970 when the temperature began to rise again. There has been a rise in temperature since the 1970's . The report states, " A straightforward statistical average of mean temperatures across the U.S. gives evidence of a rise through the century of about 0.3 to 0.4° C (0.6 to 0.8° F), although so crude a characterization of mean temperature change in the U.S. would be indeed a gross oversimplification."

"The increase in annual temperatures after the 1970s is mainly the result of significant increases of temperature during the first six months of the year (winter and spring). Temperatures during summer and autumn have changed little after dropping from conditions of the warm 1930s. Unusually high precipitation and cloud amount tend to cool the air, especially during the second half of the year. It is rare to find much above normal precipitation and cloud amount during these two seasons when temperatures are higher than normal.

"On a regional basis the West contributes most to the increase of annual average nation-wide temperatures. As with drought and excessive

moisture, portions of the country can be extremely cold at the same time that others are unusually warm, leading to an average national temperature that is near-normal. Similarly, abnormally high daytime maximum temperatures can occur while nighttime temperatures remain below normal, or vice-versa, although these are not usually the case."

TROPICAL STORMS

"Changes and variations of destructive storms are of particular interest because of their socio-economic and biophysical impact. Reliable records of the number and intensity of tropical hurricanes that reach the U.S. go back to at least 1900.Based on a commonly used classification of hurricane intensity, the studies indicates that the frequency of these violent storms that make landfall in the U.S. has been relatively low over the past few decades, as compared to the middle of the century. The decline is reflected in both the total number of hurricanes making landfall in the U.S. and in the occurrence of more destructive storms. It is difficult to discern any long-term trend however, since the frequency of hurricanes was also low in the early part of the century. Furthermore, recent studies indicate that even if significant greenhouse induced warming were to occur, it is doubtful whether increases in tropical storms would be detectable due to the large natural variability in these storms."

CHANGES IN CIRCULATION

Another factor the climatologists have studied are changes in circulation over the past few decades. Since the winter of 1976-77, the sea-surface temperatures in the central and eastern equatorial Pacific have remained anomalously warm. The report states:"Such events have been directly linked to increased precipitation in the southeastern U.S. and warmer than normal temperatures in the Pacific Northwest. During these same years a large-scale redistribution of atmospheric mass has taken place in the North Pacific, associated with a change of the upper-level steering winds over the North Pacific and North America. El Nic o events (and their opposition phases, La Nic a events) have been quantitatively linked to the 1988 drought, to increased precipitation in the South, and to other abnormal temperature conditions in the U.S. Variations in the circulation of the North Atlantic Ocean have also directly influenced the eastern U.S. climate in the form of stronger than normal winds over these regions that seem to oscillate on decadal time-scales. Such oscillations have been linked to colder than normal temperatures in the region."

CLIMATE CHANGE INDICES

"Most readers will by now agree that it is difficult to draw a simple picture that summarizes the many parameters and multidimensional aspects of observed climate change and variability, no matter how complete the record. One approach toward simplification might be to consider only long-term

measurements of a few near-surface conditions: temperature and precipitation, for example, are two primary elements of climate that affect many aspects of our lives. But neither tells the whole story.

CONCLUSIONS

"Several indicators stand out most conspicuously in the picture of surface climate variations and changes in the U.S. over the past century. These include the rather steady increase in precipitation derived from extreme 1-day precipitation events; the systematic decrease in the day-to-day variations of temperature; and the increased frequency of days with precipitation. Trends in other indicators of climate change are now neither sufficiently large nor persistent enough to be considered as strongly suggestive of systematic change, even though it remains a likely explanation. These include the increase of total precipitation and the related increase in cloud amount, as well as an overall increase in mean temperature. The area of the country that has experienced an increase in mean temperature has risen while the proportion of the country with much below normal mean minimum temperatures has decreased. Many of these indicators appear to have undergone significant change during the late 1970s and have more or less remained at these levels to the present. In contrast, other surface climate change indicators (such as the frequency of tropical cyclones) reflect the kind

of climatic variability that is completely consistent with the premise of a stable or unchanging climate.

The increase in temperature across the U.S. in this century is slightly smaller, but of comparable magnitude to the increase of temperature that has characterized the world as a whole. The increase in minimum temperature and the related increase in area affected by much above normal minimum temperatures are also found in many other countries of the northern hemisphere. Worldwide precipitation over land has changed little through the twentieth century; increases noted in high latitudes have been balanced by low-latitude decreases. By comparison, the change in precipitation in the U.S. is still relatively moderate compared to some of the increases and decreases at other latitudes. Decreases in the day-to-day differences of temperature observed in the U.S. are also apparent in China and Russia, the only other large countries analyzed as of this date. The persistent increase in the proportion of precipitation derived from extremely heavy precipitation has not been detected in these other countries.

Global warming

Introduction in Global warming

“Global warming” has been introduced by the scientific community and the media as the term that encompasses all potential changes in climate that result from higher average global temperatures. Hundreds of scientists from many different countries are working to understand global warming and have come to a consensus on several important aspects. In general, Global warming will produce far more profound climatic changes than simply a rise in global temperature. A recent study by an international panel of scientists suggested that if trends in current emissions of greenhouse gases and aerosols continue, the globe may warm by an average of 2°C by the year 2100. The average rate of warming would probably be greater than any seen in the last 10,000 years

An analysis of temperature records shows that the Earth has warmed an average of 0.5°C over the past 100 years. This is consistent with predictions of global warming due to an enhanced greenhouse effect and increased aerosols. Yet, it could also be within acceptable limits for natural temperature variation. The twelve warmest years of the twentieth century have occurred since 1980. The Earth’s warmest years since 1861 have been: 1981, 1983, 1987, 1988, 1989, 1990, 1991, 1994, 1995, 1996, 1997 and 1998. 1997 and 1998 were the two warmest years recorded during that period. This lends support to the assumption that the Earth’s

climate is warming. However, it may take another decade of continued increases in global temperatures to provide conclusive evidence that the world's climate is warming as a result of the enhanced greenhouse effect.
Global surface air temperature in 1997 was warmer than any previous year this century, marginally exceeding the temperature of 1995. Part of the current global warmth is associated with the tropical El NiЯo, without which a record global temperature would probably not have occurred. Global surface temperatures in 1998 set a new record for the period of instrumental measurements, report NASA/GISS researchers who analyzed data collected from several thousand meteorological stations around the world. The global temperature exceeded that of the previous record year, by such a wide margin that the 1998 calendar year is certain to also set a new record. The United States experienced in 1998 its warmest year in the past several decades. As for the Russia, global surface air temperatures in 1997-98 were not warmer than previous years.

Until recently, researchers were uncertain whether Climate developments reflected natural variations in the Earth, or whether in fact human activities contributed to the warming. The latest observed data reveals some striking trends:
- All 10 of the warmest years on record have occurred in the last 15 years.
- The 1990s have already been warmer than the

1980s - the warmest decade on record - by almost 0.2°F (0.1°C), according to the Goddard Institute of Space Studies.
- The global average surface temperature has risen 0.5°-1.1°F (0.3°-0.6°C) since reliable records began in the second half of the 19th century.
In 1995, scientists with the Intergovernmental Panel on Climate Change - the authoritative international body charged with studying this issue-reached a conclusion in the Second Assessment Report, which summarizes the current state of scientific knowledge on global warming, also called climate change.
For the first time ever, the Panel concluded that the observed increase in global average temperature over the last century *"is unlikely to be entirely natural in origin"* and that ***"the balance of evidence suggests that there is a discernible human influence on global climate."***

The Cause

The Earth's climate is the result of extremely complex interactions among the atmosphere, the oceans, the land masses, and living organisms, which are all warmed daily by the sun's energy. This heat would radiate back into space if not for the atmosphere, which relies on a delicate balance of heat-trapping gases - including water vapor, carbon dioxide, nitrous oxide, and methane - to act as a natural "greenhouse," keeping in just the right amount of the sun's energy to support life.

For the past 150 years, though, the atmospheric concentrations of these gases, particularly carbon dioxide, have been rising. As a result, more heat is being trapped than previously, which in turn is causing the global temperature to rise. Climate scientists have linked the increased levels of heat-trapping gases in the atmosphere to human activities, in particular the burning of fossil fuels (coal, oil, and natural gas for heating and electricity; gasoline for transportation), deforestation, cattle ranching, and rice farming. But Global Warming has received much press in the past decade. There are many questions like these ones. *Could the earth's climate really heat up? What are the causes if such a warming occurs? Is global warming a theory and thrue or false theory at that?*
These questions and more are what climate scientists are asking themselves daily. So, there are two sides to every story and both are discussed in the media.

The Impacts

As the Earth's climate is the result of extremely complex interactions, scientists still cannot predict the exact impact on the earth's climate of these rising levels of heat-trapping gases over the next century. But there is striking agreement among most climate scientists about what is likely to occur. Poureful climate models suggest that the planet will warm over the next century at a more

rapid rate than ever before recorded. The current best estimate is that if carbon dioxide concentrations double over preindustrial levels, global average surface temperatures will rise between 1.8° and 6.3°F (between 1° and 3.5°C). According to the scientific possible scenarios, an atmospheric doubling of carbon dioxide could occur as early as 2050. Future impacts from this kind of warming will most likely include: - damage to human health
- severe stress on forests, wetlands, and other natural habitats
- dislocation of agriculture and commerce
- expansion of the earth's deserts
- melting of polar ice caps and consequent rise in the sea level
- more extreme weather events

The Future and Global Warming Policy

During the 1980-90s, evidence mounted that increased atmospheric concentrations of heat-trapping gases could cause significant disruptions of the earth's climate systems. These discoveries moved the global warming issue into the arena of public policy.