

EXHIBIT 8

THE HISTORY OF CLIMATE CHANGE

THE GREENHOUSE EFFECT

1824



Joseph Fourier

Physicist and mathematician Joseph Fourier proposes the theory that the atmosphere traps heat through a greenhouse effect.

"The temperature [of the Earth] can be augmented by the interposition of the atmosphere, because heat in the state of light finds less resistance in penetrating the air, than in re-passing into the air when converted into nonluminous heat."

1856

Scientist Eunice Newton Foote discovered that the warming effect of the Sun was increased by the presence of carbon dioxide.

1859

Physicist John Tyndall conducts experiments finding that carbon dioxide, methane and other gases create the greenhouse effect.



THE HISTORY OF CLIMATE CHANGE

CARBON DIOXIDE & GLOBAL TEMPERATURE

1896



Svante Arrhenius

Chemist Svante Arrhenius calculates the effect of increasing fossil fuel use on global temperature and concludes that human emissions of carbon dioxide would warm the Earth.

"Any doubling of the percentage of carbon dioxide in the air would raise the temperature of the earth's surface by 4°; and if the carbon dioxide were increased fourfold, the temperature would rise by 8°." (1908)

1899



Thomas Chrowder Chamberlin

Geologist Thomas Chrowder Chamberlin proposes that changes in atmospheric carbon dioxide cause ice ages and interglacial warm periods.

"the effect of the carbon dioxide and water vapor is to blanket the earth with a thermally absorbent envelope."

1924



Milutin Milanković

Geophysicist and astronomer Milutin Milanković hypothesized that variations in the Earth's orbit were the primary drivers of past long-term global climate patterns (e.g., the ice ages).

1938

Engineer Guy Callendar shows that temperature had risen over the previous century, carbon dioxide concentrations had increased over the same period, and suggests this caused the warming.



Guy Callendar

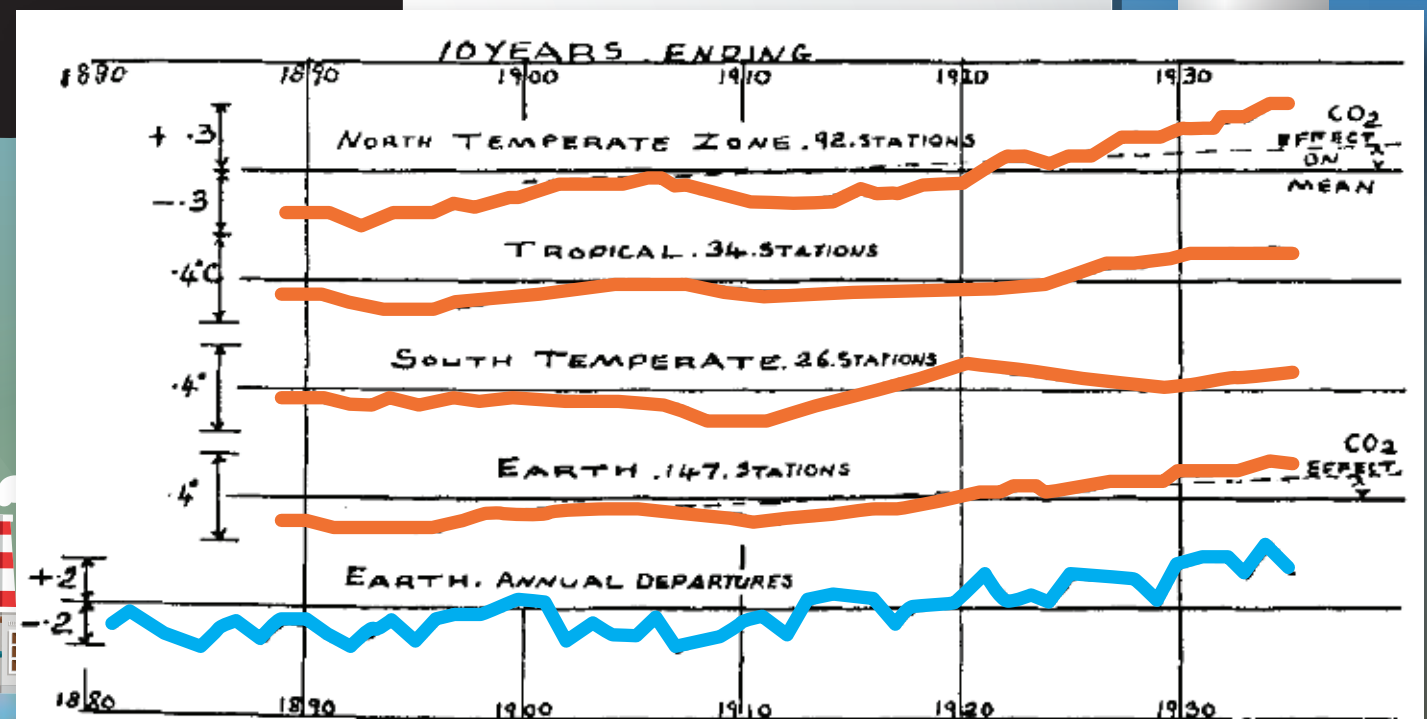


FIG. 4.—Temperature variations of the zones and of the earth. Ten-year moving departures from the mean, 1901-1930, °C.

THE HISTORY OF CLIMATE CHANGE

CARBON DIOXIDE & GLOBAL TEMPERATURE

1956



Svante Arrhenius

Scientist Gilbert Plass concludes that doubling carbon dioxide concentrations would increase temperatures by 3-4 °C.

"The addition of CO₂ to the atmosphere by industrial processes and other activities of man is increasing the CO₂ concentration of the atmosphere at the rate of nearly 30 per cent a century and causing the average temperature to rise 1.1°C per century."

1957



Roger Revelle

Oceanographer Roger Revelle and chemist Hans Suess show that seawater will not absorb all the additional CO₂ entering the atmosphere, as many other scientists had assumed. They projected that an increase of 1 °C would raise sea level by 60 cm due to thermal expansion alone.

"Human beings are now carrying out a large scale geophysical experiment."

— Revelle

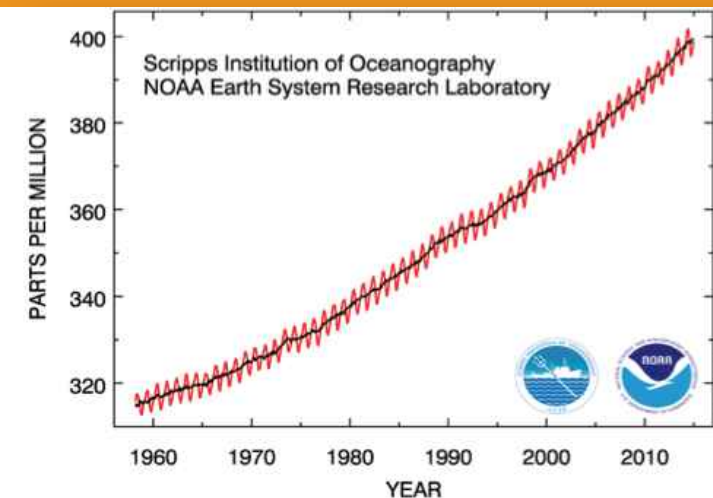
1958



Charles David Keeling

Chemist Charles David Keeling began making highly accurate observations of atmospheric carbon dioxide concentrations and provides, in 1961, the first unequivocal proof that carbon dioxide levels are rising steadily.

Carbon dioxide concentrations since 1958, measured at Mauna Loa, Hawaii



1965

The President's Science Advisory Committee under President Lyndon Johnson publishes a major report on the environment warning that the greenhouse effect is a matter of "real concern."

"Through his worldwide industrial civilization, Man is unwittingly conducting a vast geophysical experiment. Within a few generations he is burning the fossil fuels that slowly accumulated in the earth over the past 500 million years."

"The melting of the Antarctic ice cap would raise sea level by 400 feet. If 1,000 years were required to melt the ice cap, the sea level would rise about 4 feet every 10 years, 40 feet per century. This is a hundred times greater than present worldwide rates of sea level change."

RESTORING THE QUALITY
OF
OUR ENVIRONMENT



Report of The
Environmental Pollution Panel
President's Science Advisory Committee

THE WHITE HOUSE
NOVEMBER 1965

THE HISTORY OF CLIMATE CHANGE

CLIMATE SYSTEM STUDIES

1969

Scientists at NOAA's Geophysical Fluids Dynamics Laboratory (Syukuro Manabe and colleagues) develop the first three-dimensional atmosphere-ocean model of the Earth's climate system.



1974

Wallace S. Broecker publishes peer-reviewed article entitled

"Are We on the Brink of a Pronounced Global Warming?"

1975

Manabe paper based on first Global Circulation Model showing double CO₂ would raise global average temperature approximately 3.5°C.

JOURNAL OF THE ATMOSPHERIC SCIENCES

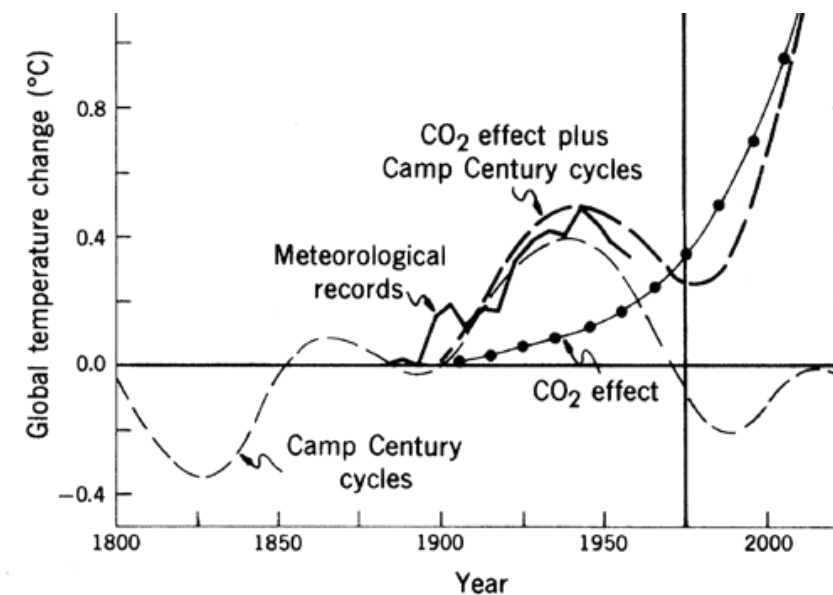
Climate Calculations with a Combined Ocean-Atmosphere Model

SYUKURO MANABE AND KIRK BRYAN

Geophysical Fluid Dynamics Laboratory, ESSA, Princeton University, Princeton, N. J.

13 March 1969 and 6 May 1969

Climatic Change: Are We on the Brink of a Pronounced Global Warming?



THE HISTORY OF CLIMATE CHANGE

CLIMATE SYSTEM STUDIES

1979

U.S. National Academy of Sciences report on Carbon Dioxide and Climate: A Scientific Assessment led by Jule Charney (often called the Charney Report).



"When it is assumed that the CO2 content of the atmosphere is doubled and statistical thermal equilibrium is achieved, the more realistic of the modeling efforts predict a global surface warming of between 2°C and 3.5°C, with greater increases at high latitudes."

1988

The Intergovernmental Panel on Climate Change created by the World Meteorological Organization and the United Nations Environment Program to prepare, based on available scientific information, assessments on all aspects of climate change and its impacts, with a view of formulating realistic response strategies.

1988

Dr. James E. Hansen, Director of Goddard Institute for Space Studies of the National Aeronautics and Space Administration, testified before U.S. Senate that it was 99 percent certain that the warming trend was not a natural variation but was caused by a buildup of carbon dioxide and other gases in the atmosphere.

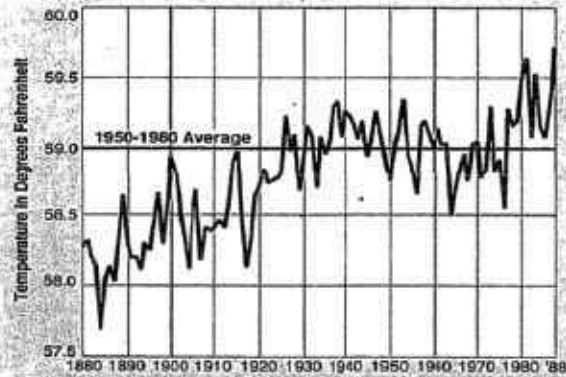


"Global Warming Has Begun"

Carbon Dioxide and Climate: A Scientific Assessment

Report of an Ad Hoc Study Group on Carbon Dioxide and Climate
Woods Hole, Massachusetts
July 23-27, 1979
to the
Climate Research Board
Assembly of Mathematical and Physical Sciences
National Research Council

Global Warming Has Begun, Expert Tells Senate



Global Warming: Greenhouse Effect?

Average global temperatures through the first five months of 1988. As a baseline, scientists use the global average from 1950 to 1980.

Source: James E. Hansen and Sergei Lebedeff

The New York Times/June 24, 1988

Sharp Cut in Burning of Fossil Fuels Is Urged to Battle Shift in Climate

By PHILIP SHABECOFF
Special to The New York Times

WASHINGTON, June 23 — The earth has been warmer in the first five months of this year than in any comparable period since measurements began 130 years ago, and the higher temperatures can now be attributed to a long-expected global warming trend linked to pollution, a space agency scientist reported today.

Until now, scientists have been cautious about attributing rising global temperatures of recent years to the predicted global warming caused by pollutants in the atmosphere, known as the "greenhouse effect." But today Dr. James E. Hansen of the National Aeronautics and Space Administration told a Congressional committee that it was 99 percent certain that the warming trend was not a natural variation but was caused by a buildup of carbon dioxide and other artificial gases in the atmosphere.

An Impact Lasting Centuries

Drought Raising Food Prices:

THE HISTORY OF CLIMATE CHANGE

CLIMATE SYSTEM STUDIES

1990

IPCC First Assessment Report concludes that temperatures have risen by 0.3-0.6C over the last century, that humanity's emissions are adding to the atmosphere's natural complement of greenhouse gases, and that the addition would be expected to result in warming.

"we are certain" that "emissions resulting from human activities are substantially increasing the atmospheric concentrations of the greenhouse gases," including carbon dioxide and methane, and that "[t]hese increases will enhance the greenhouse effect,

resulting on average in an additional warming of the Earth's surface."

1995

IPCC Second Assessment Report

"The balance of evidence suggests a discernible human influence on global climate."

2001

IPCC Third Assessment Report finds "new and stronger evidence" that humanity's emissions of greenhouse gases are the main cause of the warming seen in second half of the 20th Century.

"There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities."



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CLIMATE SYSTEM STUDIES

2007

IPCC Fourth Assessment Report concludes it is more than 90% likely that humanity's emissions of greenhouse gases are responsible for modern-day climate change.

"Most of the observed increase in global average temperatures since the mid-20th century is likely due to the observed increase in anthropogenic greenhouse gas concentrations. Discernible human influences now extend to other aspects of climate, including ocean warming, continental-average temperatures, temperature extremes and wind patterns."

2013

The Mauna Loa Observatory on Hawaii reports that the daily mean concentration of CO₂ in the atmosphere has surpassed 400 parts per million (ppm) for the first time since measurements began in 1958 – the highest level in the past several million years.

2013

IPCC Fifth Assessment Report says scientists are 95% certain that humans are the "dominant cause" of global warming since the 1950s.

"Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia."

2014

The 3rd U.S. National Climate Assessment found that climate change is already affecting the American people in far-reaching ways.

"The global climate is changing and this is apparent across the United States in a wide range of observations. The global warming of the past 50 years is primarily due to human activities, predominantly the burning of fossil fuels."



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CLIMATE SYSTEM STUDIES

2017

The 4th U.S. National Climate Assessment found stronger evidence has emerged for continuing, rapid, human-caused warming of the global atmosphere and ocean.

2018

Carbon dioxide levels now exceed 410 ppm.

