# Global warming - physicist's perspective - 04

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University of Warsaw, Faculty of Physics, Institute of Geophysics

Time-line (milestones)
(after http://www.aip.org/history/climate/timeline.htm and other sources)

**1801** – Herschel chypothesizes on the effects of variablee solar emission om climate

**1824** - Fourier calculates that the Earth would be far colder if it lacked an atmosphere and introduces term „greenhouse effect”

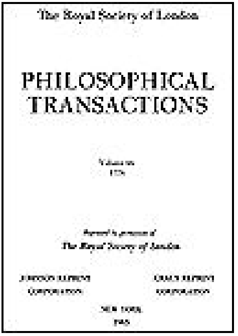
**1859** - Tyndall discovers that some gases absorb infrared radiation. He suggests that changes in the concentration of the gases could bring climate change.

**1896** - Arrhenius publishes first calculation of global warming from increased concentrations of CO2.

**1897** - Chamberlin produces a model for global carbon exchange including feedbacks.

**1930s**: Global warming trend since late 19th century reported.
Milankovitch proposes orbital changes as the cause of ice ages.
Hulburt publishes calculations of warming from increased concentrations of CO2.

**1938** - Callendar argues that CO2 greenhouse global warming is underway, reviving interest in the problem.






# XIII. *Observations tending to investigate the Nature of the Sun, in order to find the Causes or Symptoms of its variable Emission of Light and Heat; with Remarks on the Use that may possibly be drawn from Solar Observations. By* William Herschel, *L.L.D. F.R.S.*

Read April 16, 1801.

On a former occasion I have shewn, that we have great reason to look upon the sun as a most magnificent habitable globe; and, from the observations which will be related in this Paper, it will now be seen, that all the arguments we have used before are not only confirmed, but that we are encouraged to go a considerable step farther, in the investigation of the physical and planetary construction of the sun. The influence of this eminent body, on the globe we inhabit, is so great, and so widely diffused, that it becomes almost a duty for us to study the operations which are carried on upon the solar surface. Since light and heat are so essential to our well-being, it must certainly be right for us to look into the source from whence they are derived, in order to see whether some material advantage may not be drawn from a thorough acquaintance with the causes from which they originate.

A similar motive engaged the Egyptians formerly to study and watch the motions of the Nile; and to construct instruments for measuring its rise with accuracy. They knew very well, that it was not in their power to add a single inch to the



Observations Tending to Investigate the Nature of the Sun, in Order to Find the Causes or Symptoms of Its Variable Emission of Light and Heat; With Remarks on the Use That May Possibly Be Drawn from Solar Observations

William Herschel

Philosophical Transactions of the Royal Society of London
Vol. 91 (1801), pp. 265-318

Two basic climate mechanisms were known in the beginning of XIX century !!!

# MÉMOIRES

DE

L'ACADÉMIE ROYALE DES SCIENCES

DE L'INSTITUT

DE FRANCE.

TOME VII.

PARIS,

CHEZ FIRMIN DIDOT, PÈRE ET FILS, LIBRAIRES,

RUE JACOB, N° 24.

1827.

# MÉMOIRE

SUR

LES TEMPÉRATURES DU GLOBE TERRESTRE ET DES ESPACES PLANÉTAIRES.

PAR M. FOURIER.

La question des températures terrestres, l'une des plus importantes et des plus difficiles de toute la philosophie naturelle, se compose d'éléments assez divers qui doivent être considérés sous un point de vue général. J'ai pensé qu'il serait utile de réunir dans un seul écrit les conséquences principales de cette théorie; les détails analytiques que l'on omet ici se trouvent pour la plupart dans les ouvrages que j'ai déja publiés. J'ai désiré surtout présenter aux physiciens, dans un tableau peu étendu, l'ensemble des phénomènes et les rapports mathématiques qu'ils ont entre eux.

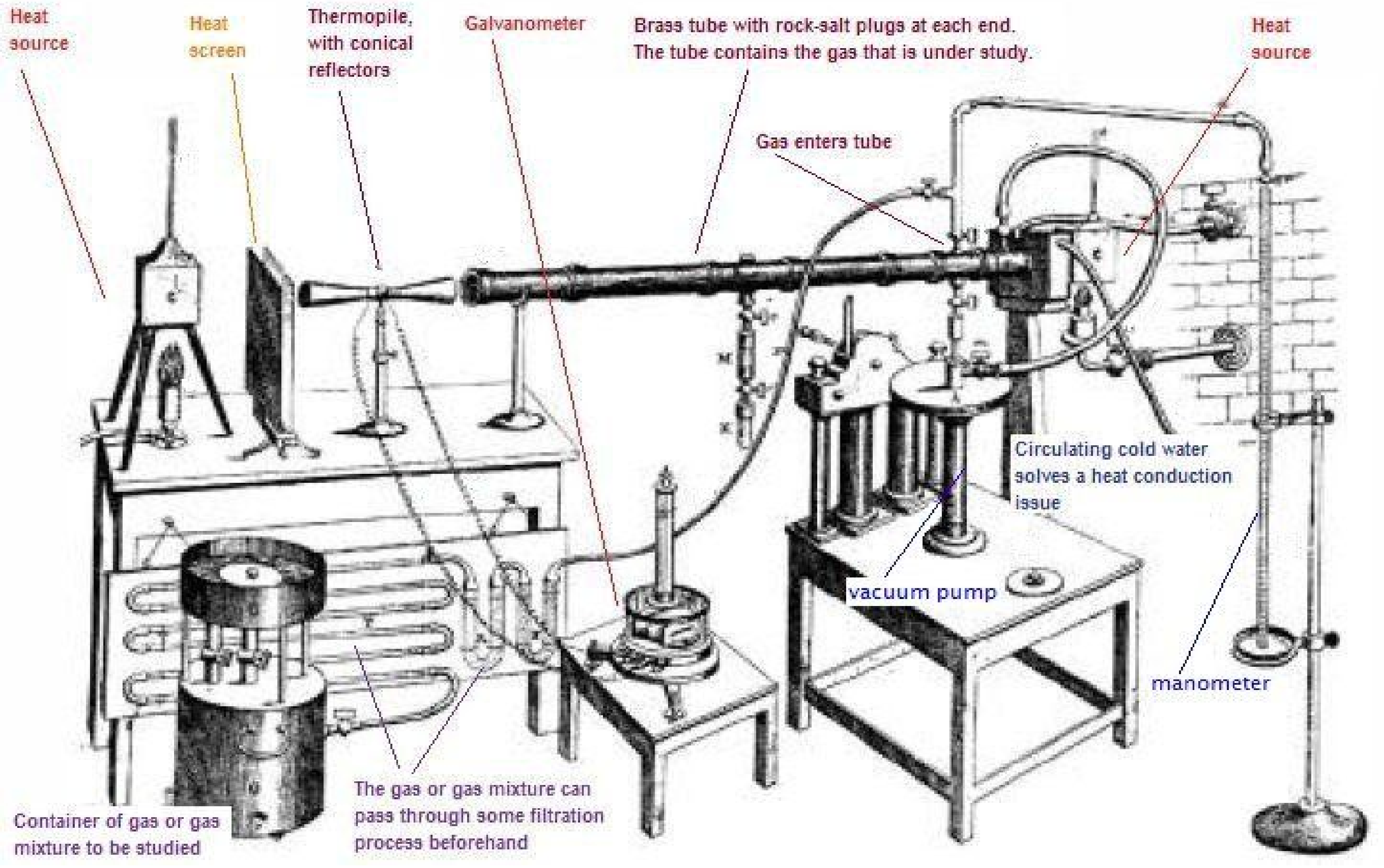
La chaleur du globe terrestre dérive de trois sources qu'il est d'abord nécessaire de distinguer.

1° La terre est échauffée par les rayons solaires, dont l'inégale distribution produit la diversité des climats.

2° Elle participe à la température commune des espaces planétaires, étant exposée à l'irradiation des astres innombrables qui environnent de toutes parts le système solaire.



Fourier J (1827). "Mémoire Sur Les Températures Du Globe Terrestre Et Des Espaces Planétaires". Mémoires de l'Académie Royale des Sciences 7: 569–604




1861, Tyndall's apparatus measuring properties of greenhouse gases.

# *On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground*

Svante Arrhenius

Philosophical Magazine and Journal of Science
Series 5, Volume 41, April 1896, pages 237-276.



Arrhenius's paper is the first to quantify the contribution of carbon dioxide to the greenhouse effect (Sections I-IV) and to speculate about whether variations in the atmospheric concentration of carbon dioxide have contributed to long-term variations in climate (Section V). Throughout this paper, Arrhenius refers to carbon dioxide as "carbonic acid" in accordance with the convention at the time he was writing.

Contrary to some misunderstandings, Arrhenius does not explicitly suggest in this paper that the burning of fossil fuels will cause global warming, though it is clear that he is aware that fossil fuels are a potentially significant source of carbon dioxide (page 270), and he does explicitly suggest this outcome in later work.

THE

LONDON, EDINBURGH, AND DUBLIN

PHILOSOPHICAL MAGAZINE

AND

JOURNAL OF SCIENCE.

[FIFTH SERIES.]

*APRIL* 1896.

XXXI. *On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground.* *By* Prof. SVANTE ARRHENIUS *.

## I. *Introduction: Observations of* Langley *on Atmospherical Absorption.*

A GREAT deal has been written on the influence of the absorption of the atmosphere upon the climate. Tyndall † in particular has pointed out the enormous importance of this question. To him it was chiefly the diurnal and annual variations of the temperature that were lessened by this circumstance. Another side of the question, that has long attracted the attention of physicists, is this: Is the mean temperature of the ground in any way influenced by the presence of heat-absorbing gases in the atmosphere? Fourier‡ maintained that the atmosphere acts like the glass of a hot-house, because it lets through the light rays of the sun but retains the dark rays from the ground. This idea was elaborated by Pouillet §; and Langley was by some of his researches led to the view, that "the temperature of the earth under direct sunshine, even though our atmosphere were present as now, would probably fall to −200° C., if that atmosphere did not possess the quality of selective

* Extract from a paper presented to the Royal Swedish Academy of Sciences, 11th December, 1895. Communicated by the Author.
† 'Heat a Mode of Motion,' 2nd ed. p. 405 (Lond., 1865).
‡ *Mém. de l'Ac. R. d. Sci. de l'Inst. de France*, t. vii. 1827.
§ *Comptes rendus*, t. vii. p. 41 (1838).

TABLE VII.—*Variation of Temperature caused by a given Variation of Carbonic Acid.*

| Latitude. | Carbonic Acid=0·67. | | | | | Carbonic Acid=1·5. | | | | | Carbonic Acid=2·0. | | | | | Carbonic Acid=2·5. | | | | | Carbonic Acid=3·0. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Dec.–Feb. | March–May. | June–Aug. | Sept.–Nov. | Mean of the year. | Dec.–Feb. | March–May. | June–Aug. | Sept.–Nov. | Mean of the year. | Dec.–Feb. | March–May. | June–Aug. | Sept.–Nov. | Mean of the year. | Dec.–Feb. | March–May. | June–Aug. | Sept.–Nov. | Mean of the year. | Dec.–Feb. | March–May. | June–Aug. | Sept.–Nov. | Mean of the year. |
| 70–60 | −2·9 | −3·0 | −3·4 | −3·1 | −3·1 | 3·3 | 3·4 | 3·8 | 3·6 | 3·52 | 6·0 | 6·1 | 6·0 | 6·1 | 6·05 | 7·9 | 8·0 | 7·9 | 8·0 | 7·95 | 9·1 | 9·3 | 9·4 | 9·4 | 9·3 |
| 60–50 | −3·0 | −3·2 | −3·4 | −3·3 | −3·22 | 3·4 | 3·7 | 3·6 | 3·8 | 3·62 | 6·1 | 6·1 | 5·8 | 6·1 | 6·02 | 8·0 | 8·0 | 7·6 | 7·9 | 7·87 | 9·3 | 9·5 | 8·9 | 9·5 | 9·3 |
| 50–40 | −3·2 | −3·3 | −3·3 | −3·4 | −3·3 | 3·7 | 3·8 | 3·4 | 3·7 | 3·65 | 6·1 | 6·1 | 5·5 | 6·0 | 5·92 | 8·0 | 7·9 | 7·0 | 7·9 | 7·7 | 9·5 | 9·4 | 8·6 | 9·2 | 9·17 |
| 40–30 | −3·4 | −3·4 | −3·2 | −3·3 | −3·32 | 3·7 | 3·6 | 3·3 | 3·5 | 3·52 | 6·0 | 5·8 | 5·4 | 5·6 | 5·7 | 7·9 | 7·6 | 6·9 | 7·3 | 7·42 | 9·3 | 9·0 | 8·2 | 8·8 | 8·82 |
| 30–20 | −3·3 | −3·2 | −3·1 | −3·1 | −3·17 | 3·5 | 3·3 | 3·2 | 3·5 | 3·47 | 5·6 | 5·4 | 5·0 | 5·2 | 5·3 | 7·2 | 7·0 | 6·6 | 6·7 | 6·87 | 8·7 | 8·3 | 7·5 | 7·9 | 8·1 |
| 20–10 | −3·1 | −3·1 | −3·0 | −3·1 | −3·07 | 3·5 | 3·2 | 3·1 | 3·2 | 3·25 | 5·2 | 5·0 | 4·9 | 5·0 | 5·02 | 6·7 | 6·6 | 6·3 | 6·6 | 6·52 | 7·9 | 7·5 | 7·2 | 7·5 | 7·52 |
| 10–0 | −3·1 | −3·0 | −3·0 | −3·0 | −3·02 | 3·2 | 3·2 | 3·1 | 3·1 | 3·15 | 5·0 | 5·0 | 4·9 | 4·9 | 4·95 | 6·6 | 6·4 | 6·3 | 6·4 | 6·42 | 7·4 | 7·3 | 7·2 | 7·3 | 7·3 |
| 0–(−10) | −3·0 | −3·0 | −3·1 | −3·0 | −3·02 | 3·1 | 3·1 | 3·2 | 3·2 | 3·15 | 4·9 | 4·9 | 5·0 | 5·0 | 4·95 | 6·4 | 6·4 | 6·6 | 6·6 | 6·5 | 7·3 | 7·3 | 7·4 | 7·4 | 7·35 |
| −10–(−20) | −3·1 | −3·1 | −3·2 | −3·1 | −3·12 | 3·2 | 3·2 | 3·2 | 3·2 | 3·2 | 5·0 | 5·0 | 5·2 | 5·1 | 5·07 | 6·6 | 6·6 | 6·7 | 6·7 | 6·65 | 7·4 | 7·5 | 8·0 | 7·6 | 7·62 |
| −20–(−30) | −3·1 | −3·2 | −3·3 | −3·2 | −3·2 | 3·2 | 3·2 | 3·4 | 3·3 | 3·27 | 5·2 | 5·3 | 5·5 | 5·4 | 5·35 | 6·7 | 6·8 | 7·0 | 7·0 | 6·87 | 7·9 | 8·1 | 8·6 | 8·3 | 8·22 |
| −30–(−40) | −3·3 | −3·3 | −3·4 | −3·4 | −3·35 | 3·4 | 3·5 | 3·7 | 3·5 | 3·52 | 5·5 | 5·6 | 5·8 | 5·6 | 5·62 | 7·0 | 7·2 | 7·7 | 7·4 | 7·32 | 8·6 | 8·7 | 9·1 | 8·8 | 8·8 |
| −40–(−50) | −3·4 | −3·4 | −3·3 | −3·4 | −3·37 | 3·6 | 3·7 | 3·8 | 3·7 | 3·7 | 5·8 | 6·0 | 6·0 | 6·0 | 5·95 | 7·7 | 7·9 | 7·9 | 7·9 | 7·85 | 9·1 | 9·2 | 9·4 | 9·3 | 9·25 |
| −50–(−60) | −3·2 | −3·3 | — | — | — | 3·8 | 3·7 | — | — | — | 6·0 | 6·1 | — | — | — | 7·9 | 8·0 | — | — | — | 9·4 | 9·5 | — | — | — |

## ADDENDUM*.

As the nebulosity is very different in different latitudes, and also different over the sea and over the continents, it is evident that the influence of a variation in the carbonic acid of the air will be somewhat different from that calculated above, where it is assumed that the nebulosity is the same over the whole globe. I have therefore estimated the nebulosity at different latitudes with the help of the chart published by Teisserenc de Bort, and calculated the following table for

| Latitude. | Nebulosity. | | Continent per cent. | Reduction factor. | | | K=0·67. | | K=1·5. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Conti-nent. | Ocean. | | Conti-nent. | Ocean. | Mean. | Conti-nent. | Ocean. | Conti-nent. | Ocean. |
| 70 | | | | | | | | | | |
| | 58·1 | 66·7 | 72·1 | 0·899 | 0·775 | 0·864 | −2·8 | −2·4 | 3·1 | 2·7 |
| 60 | | | | | | | | | | |
| | 56·3 | 67·6 | 55·8 | 0·924 | 0·763 | 0·853 | −3·0 | −2·4 | 3·3 | 2·7 |
| 50 | | | | | | | | | | |
| | 45·7 | 63·3 | 52·9 | 1·057 | 0·813 | 0·942 | −3·5 | −2·7 | 3·8 | 2·9 |
| 40 | | | | | | | | | | |
| | 36·5 | 52·5 | 42·9 | 1·177 | 0·939 | 1·041 | −3·9 | −3·1 | 4·1 | 3·3 |
| 30 | | | | | | | | | | |
| | 28·5 | 47·2 | 38·8 | 1·296 | 1·009 | 1·120 | −4·1 | −3·2 | 4·5 | 3·5 |
| 20 | | | | | | | | | | |
| | 28·5 | 47·0 | 24·2 | 1·308 | 1·017 | 1·087 | −4·1 | −3·2 | 4·3 | 3·4 |
| 10 | | | | | | | | | | |
| | 50·1 | 56·7 | 23·3 | 1·031 | 0·903 | 0·933 | −3·1 | −2·7 | 3·3 | 2·9 |
| 0 | | | | | | | | | | |
| | 54·8 | 59·7 | 24·2 | 0·97 | 0·867 | 0·892 | −2·9 | −2·6 | 3·1 | 2·8 |
| −10 | | | | | | | | | | |
| | 47·8 | 54·0 | 22·5 | 1·056 | 0·932 | 0·96 | −3·3 | −2·9 | 3·4 | 3·0 |
| −20 | | | | | | | | | | |
| | 29·6 | 49·6 | 23·3 | 1·279 | 0·979 | 0·972 | −4·1 | −3·1 | 4·2 | 3·2 |
| −30 | | | | | | | | | | |
| | 38·9 | 51·0 | 12·5 | 1·152 | 0·958 | 0·982 | −3·8 | −3·2 | 4·0 | 3·4 |
| −40 | | | | | | | | | | |
| | 62·0 | 61·1 | 2·5 | 0·86 | 0·837 | 0·838 | −2·9 | −2·8 | 3·2 | 3·1 |
| −50 | | | | | | | | | | |
| | 71·0 | 71·5 | 0·9 | 0·749 | 0·719 | 0·719 | | | | |
| −60 | | | | | | | | | | |

* *Cf.* p. 265.

Arrhenius wyliczył też dodatkowo poprawkę na nieprzeźroczystość atmosfery (aerozole!!!!)

**An Attempt to Frame a Working Hypothesis of the Cause of Glacial Periods on an Atmospheric Basis**

T. C. Chamberlin The Journal of Geology Vol. 7, No. 6 (Sep. - Oct., 1899), pp. 545-584

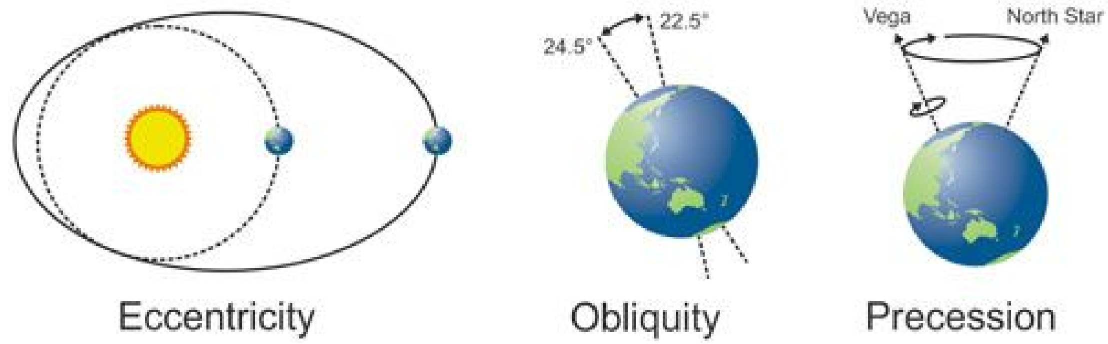
# AN ATTEMPT TO FRAME A WORKING HYPOTHESIS OF THE CAUSE OF GLACIAL PERIODS ON AN ATMOSPHERIC BASIS [1]

THERE are hypotheses and working hypotheses. The suggestion that the last glacial period was caused by the passage of the solar system through a cold region of space may be styled a hypothesis, but scarcely a working hypothesis in the geological sense, for it does not form the groundwork or incentive of geological inquiry. An astronomer might be moved to hunt for the cold spot, but it has no inspiration for the geologist. General suggestions of a possible cause do not reach the dignity of working hypotheses until they are given concrete form, are fitted in detail to the specific phenomena, and are made the agents of calling into play effective lines of research. The construction of a concrete working hypothesis suited to stimulate and guide investigation in a wholesome manner, and to take its place in competition with other hypotheses of like working potentialities, thereby inducing a more searching scrutiny of the phenomena and a more varied application of interpretations, represents the higher limit of present reasonable aspiration. It is much too ambitious to hope for a demonstrative solution of the origin of the earth's glacial periods by first intention in the present state of knowledge.

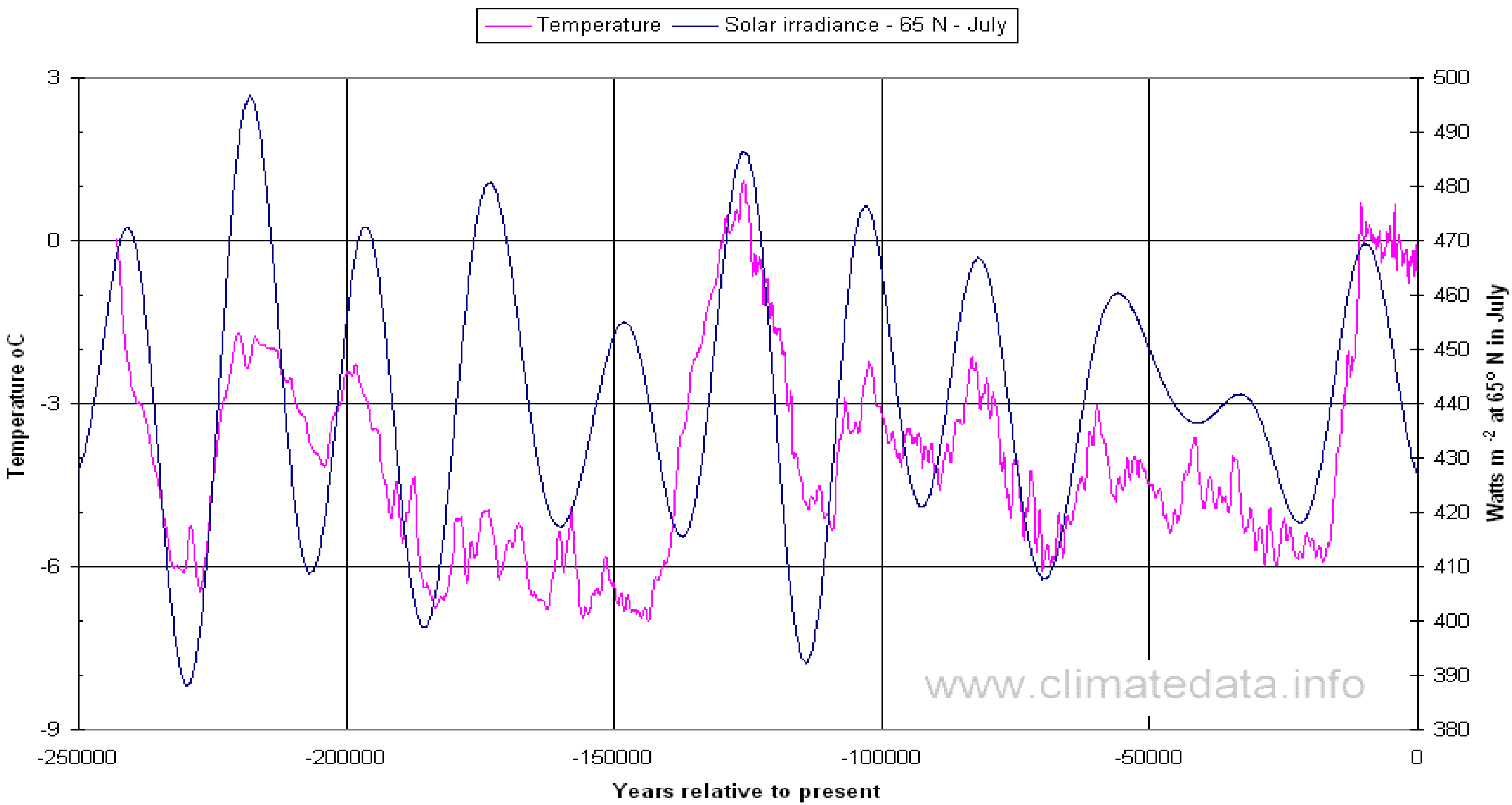
The hypothesis here offered is not worked out into satisfactory detail at all points, but it is hoped that it is sufficiently matured to justify a preliminary statement. In forming it, which has been the work of several years, I have found, or seemed to find, the phenomena of past glaciation intimately associated with a long chain of other phenomena to which at

[1] A brief statement of the salient features of this hypothesis was given in a paper entitled A Group of Hypotheses Bearing on Climatic Changes, JOUR. GEOL., Vol. V, pp. 653–683, Oct.–Nov. 1897. For earlier history see footnotes on pp. 654 and 681 of that paper.

# Milankovitch Cycles




**Milankovitch Cycles and Temperature from Vostok Ice-core**



QUARTERLY JOURNAL
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Article

# The artificial production of carbon dioxide and its influence on temperature

FREE

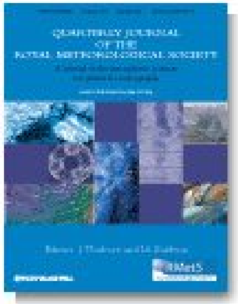
G. S. Callendar

Article first published online: 10 SEP 2007

DOI: 10.1002/qj.49706427503



Issue



Quarterly Journal of the Royal Meteorological Society

Volume 64, Issue 275, pages 223–240, April 1938



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## Abstract

By fuel combustion man has added about 150,000 million tons of carbon dioxide to the air during the past half century. The author estimates from the best available data that approximately three quarters of this has remained in the atmosphere.

The radiation absorption coefficients of carbon dioxide and water vapour are used to show the effect of carbon dioxide on "sky radiation." From this the increase in mean temperature, due to the artificial production of carbon dioxide, is estimated to be at the rate of 0.003°C. per year at the present time.

The temperature observations a t zoo meteorological stations are used to show that world temperatures have actually increased at an average rate of 0.005°C. per year during the past half century.

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**1956** -Phillips produces a computer model of the global atmosphere, Plass calculates again that radiation balance depends on $CO_2$ concentration

**1957** -Revelle and Suess demonstrate that only a fraction (about ½) of $CO_2$ produced by humans absorbed by the oceans.

**1960** - Keeling detects an annual rise of $CO_2$ in the atmosphere.

**1965** - Lorenz points out the chaotic nature of climate system and the possibility of sudden shifts.

**1966** - Emiliani's analysis of deep-sea cores and Broecker's analysis of corals show that the timing of ice ages was set by small orbital shifts.

**1979** - US National Academy of Sciences report finds that doubling $CO_2$ will bring 1.5-4.5°C global warming.

**1990** - First IPCC report says world has been warming and future warming seems likely.

**1991** - Mt. Pinatubo explodes; Hansen predicts cooling pattern, verifying (by 1995) computer models of aerosol effects.

# Carbon Dioxide Exchange Between Atmosphere and Ocean and the Question of an Increase of Atmospheric $CO_2$ during the Past Decades

By ROGER REVELLE and HANS E. SUESS, Scripps Institution of Oceanography, University of California, La Jolla, California

(Manuscript received September 4, 1956)

*Abstract*

From a comparison of $C^{14}/C^{12}$ and $C^{13}/C^{12}$ ratios in wood and in marine material and from a slight decrease of the $C^{14}$ concentration in terrestrial plants over the past 50 years it can be concluded that the average lifetime of a $CO_2$ molecule in the atmosphere before it is dissolved into the sea is of the order of 10 years. This means that most of the $CO_2$ released by artificial fuel combustion since the beginning of the industrial revolution must have been absorbed by the oceans. The increase of atmospheric $CO_2$ from this cause is at present small but may become significant during future decades if industrial fuel combustion continues to rise exponentially.

Present data on the total amount of $CO_2$ in the atmosphere, on the rates and mechanisms of exchange, and on possible fluctuations in terrestrial and marine organic carbon, are inadequate for accurate measurement of future changes in atmospheric $CO_2$. An opportunity exists during the International Geophysical Year to obtain much of the necessary information.

(Tellus, 9, 1957, 18–27)

"Human beings are now carrying out a large scale geophysical experiment of a kind that could not have happened in the past nor be reproduced in the future. Within a few centuries, we are returning to the atmosphere and oceans the concentrated organic carbon stored in sedimentary rocks over hundreds of millions of years."

# The Carbon Dioxide Theory of Climatic Change

By GILBERT N. PLASS

The Johns Hopkins University, Baltimore, Md.[1]

(Manuscript received August 9 1955)

## Abstract

The most recent calculations of the infra-red flux in the region of the 15 micron $CO_2$ band show that the average surface temperature of the earth increases 3.6° C if the $CO_2$ concentration in the atmosphere is doubled and decreases 3.8° C if the $CO_2$ amount is halved, provided that no other factors change which influence the radiation balance. Variations in $CO_2$ amount of this magnitude must have occurred during geological history; the resulting temperature changes were sufficiently large to influence the climate. The $CO_2$ balance is discussed. The $CO_2$ equilibrium between atmosphere and oceans is calculated with and without $CaCO_3$ equilibrium, assuming that the average temperature changes with the $CO_2$ concentration by the amount predicted by the $CO_2$ theory. When the total $CO_2$ is reduced below a critical value, it is found that the climate continuously oscillates between a glacial and an inter-glacial stage with a period of tens of thousands of years; there is no possible stable state for the climate. Simple explanations are provided by the $CO_2$ theory for the increased precipitation at the onset of a glacial period, the time lag of millions of years between periods of mountain building and the ensuing glaciation, and the severe glaciation at the end of the Carboniferous. The extra $CO_2$ released into the atmosphere by industrial processes and other human activities may have caused the temperature rise during the present century. In contrast with other theories of climate, the $CO_2$ theory predicts that this warming trend will continue, at least for several centuries.

### Introduction

In 1861, TYNDALL wrote that "if, as the above periments indicated, the chief influence be ercised by the aqueous vapour, every variaon of this constituent must produce a change climate. Similar remarks would apply to the rbonic acid diffused through the air . . . may have produced all the mutations of climate which the researches of geologists reveal. However this may be, the facts above cited remain: they constitute true causes, the *extent* alone of the operation remaining doubtful." A century of scientific work has been necessary in order to calculate with any

Wallace S. Broecker, Science, Vol. 189, No. 4201 (Aug. 8, 1975), 460-463

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

Abstract. *If man-made dust is unimportant as a major cause of climatic change, then a strong case can be made that the present cooling trend will, within a decade or so, give way to a pronounced warming induced by carbon dioxide. By analogy with similar events in the past, the natural climatic cooling which, since 1940, has more than compensated for the carbon dioxide effect, will soon bottom out. Once this happens, the exponential rise in the atmospheric carbon dioxide content will tend to become a significant factor and by early in the next century will have driven the mean planetary temperature beyond the limits experienced during the last 1000 years.*

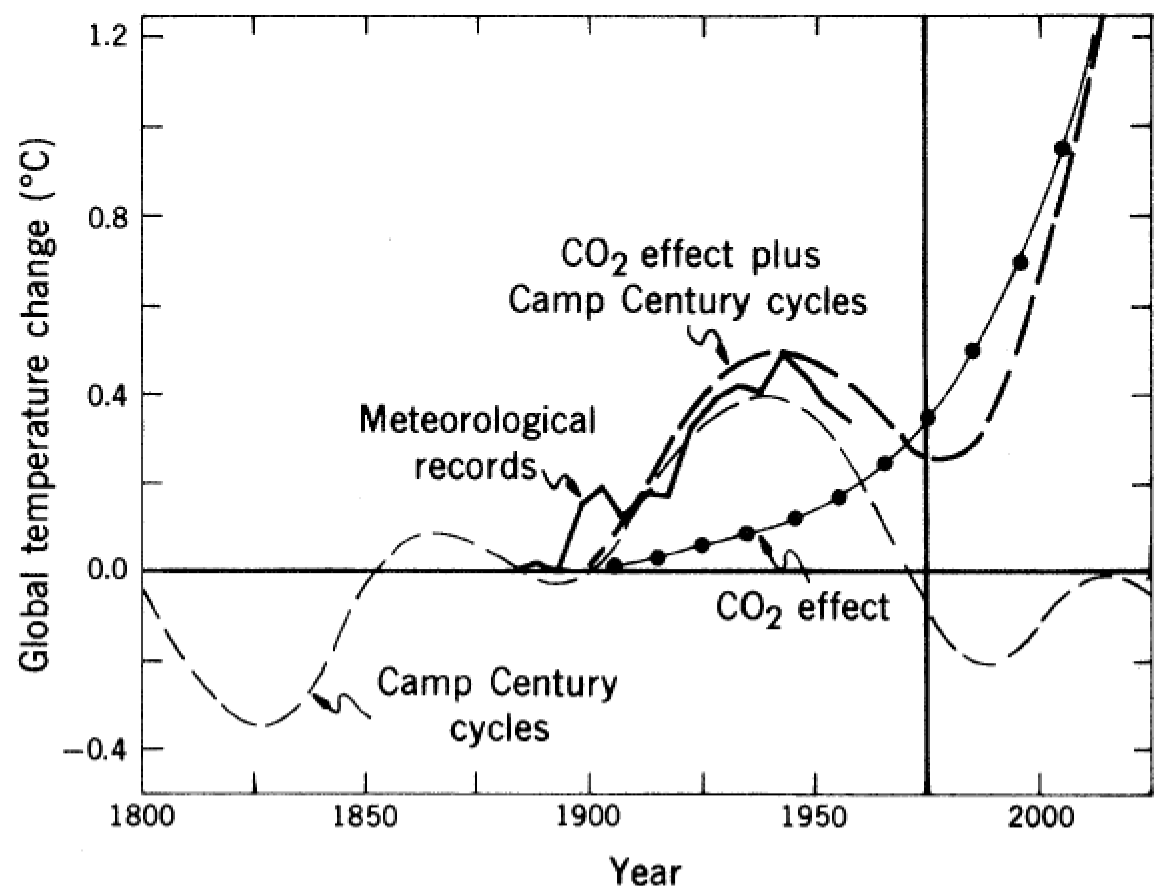



Fig. 1. Curves for the global temperature change due to chemical fuel $CO_2$, natural climatic cycles, and the sum of the two effects. The measured temperature anomaly for successive 5-year means from meteorological records over the last century is given for comparison.

# Carbon Dioxide and Climate: A Scientific Assessment

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

## Ad Hoc Study Group on Carbon Dioxide and Climate

Jule G. Charney, Massachusetts Institute of Technology, *Chairman*
Akio Arakawa, University of California, Los Angeles
D. James Baker, University of Washington
Bert Bolin, University of Stockholm
Robert E. Dickinson, National Center for Atmospheric Research
Richard M. Goody, Harvard University
Cecil E. Leith, National Center for Atmospheric Research
Henry M. Stommel, Woods Hole Oceanographic Institution
Carl I. Wunsch, Massachusetts Institute of Technology

We have examined the principal attempts to simulate the effects of increased atmospheric $CO_2$ on climate. In doing so, we have limited our considerations to the direct climatic effects of steadily rising atmospheric concentrations of $CO_2$ and have assumed a rate of $CO_2$ increase that would lead to a doubling of airborne concentrations by some time in the first half of the twenty-first century.

When it is assumed that the $CO_2$ 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. This range reflects both uncertainties in physical understanding and inaccuracies arising from the need to reduce the mathematical problem to one that can be handled by even the fastest available electronic computers. It is significant, however, that none of the model calculations predicts negligible warming.

The primary effect of an increase of $CO_2$ is to cause more absorption of thermal radiation from the earth's surface and thus to increase the air temperature in the troposphere. A strong positive feedback mechanism is the accompanying increase of moisture, which is an even more powerful absorber of terrestrial radiation. We have examined with care all known negative feedback mechanisms, such as increase in low or middle cloud amount, and have concluded that the oversimplifications and inaccuracies in the models are not likely to have vitiated the principal conclusion that there will be appreciable warming. The known negative feedback mechanisms can reduce the warming, but they do not appear to be so strong as the positive moisture feedback. We estimate the most probable global warming for a doubling of $CO_2$ to be near 3°C with a probable error of ± 1.5°C. Our estimate is based primarily on our review of a series of calculations with three-dimensional models of the global atmospheric circulation, which is summarized in Chapter 4. We have also reviewed simpler models that appear to contain the main physical factors.

To summarize, we have tried but have been unable to find any overlooked or underestimated physical effects that could reduce the currently estimated global warmings due to a doubling of atmospheric $CO_2$ to negligible proportions or reverse them altogether. However, we believe it quite possible that the capacity of the intermediate waters of the oceans to absorb heat could delay the estimated warming by several decades. It appears that the warming will eventually occur, and the associated regional climatic changes so important to the assessment of socioeconomic consequences may well be significant, but unfortunately the latter cannot yet be adequately projected.

28 August 1981, Volume 213, Number 4511

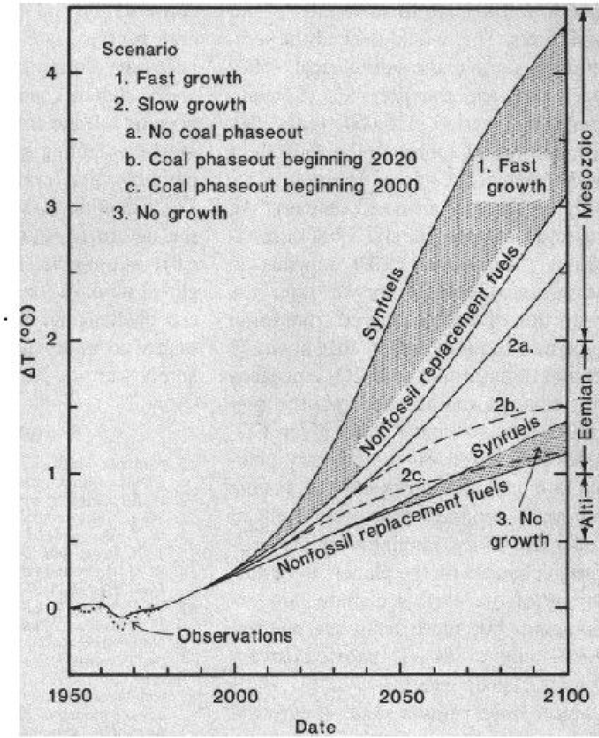
SCIENCE

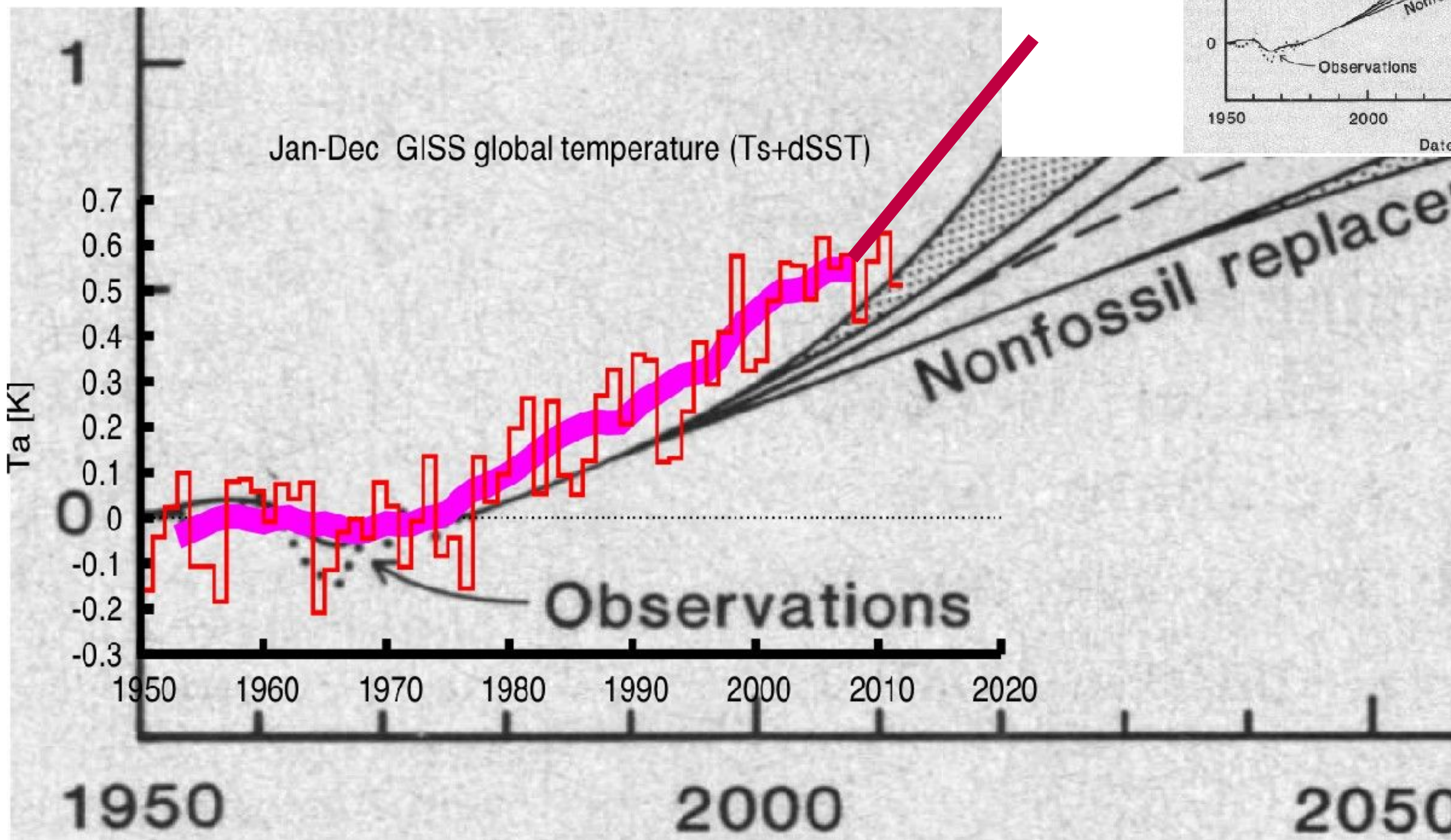
# Climate Impact of Increasing Atmospheric Carbon Dioxide

J. Hansen, D. Johnson, A. Lacis, S. Lebedeff

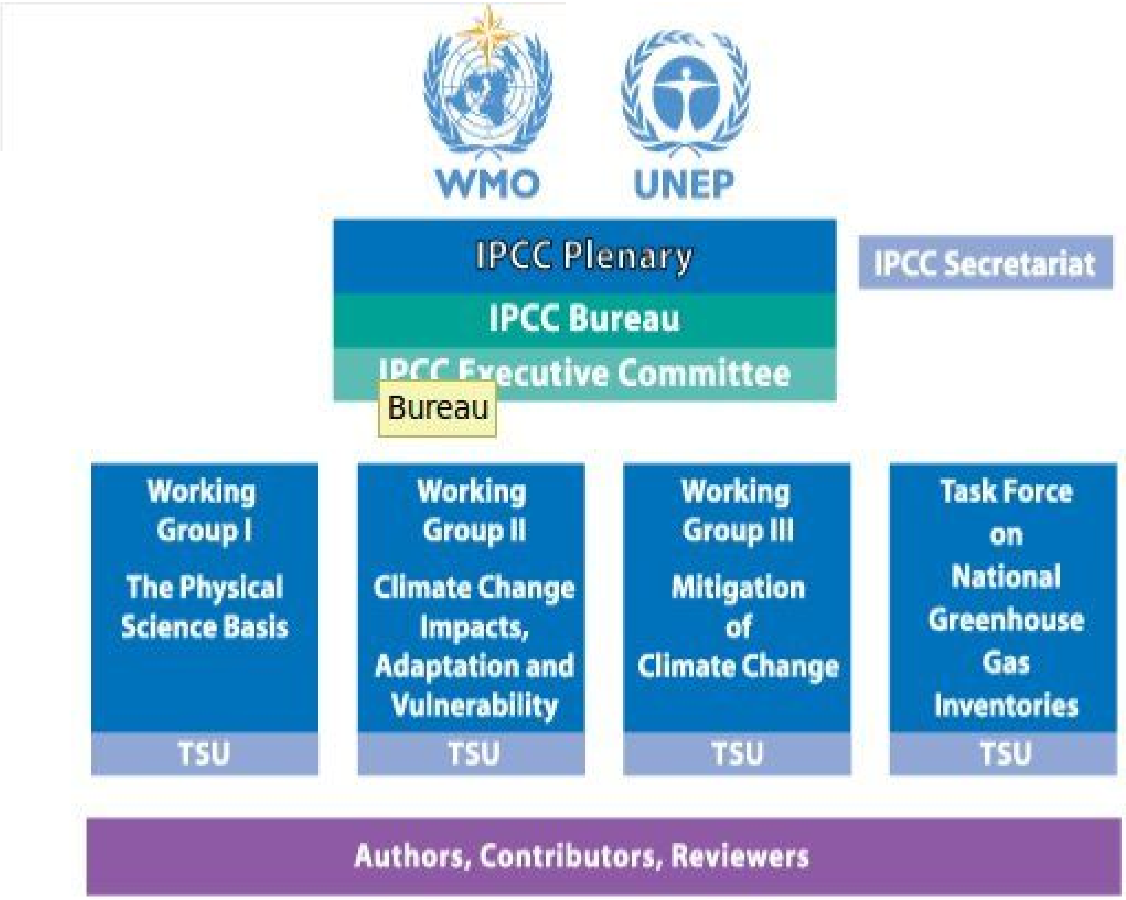
P. Lee, D. Rind, G. Russell

Fig. 6. Projections of global temperature. The diffusion coefficient beneath the ocean mixed layer is 1.2 $cm^2$ $sec^{-1}$, as required for best fit of the model and observations for the period 1880 to 1978. Estimated global mean warming in earlier warm periods is indicated on the right.



The Intergovernmental Panel on Climate Change (IPCC), established in 1988 is the United Nations body for assessing the science related to climate change



## IPCC First Assessment Report 1990 (FAR)

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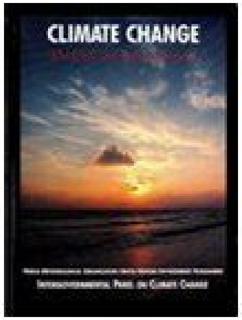


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Scientific Assessment of Climate Change
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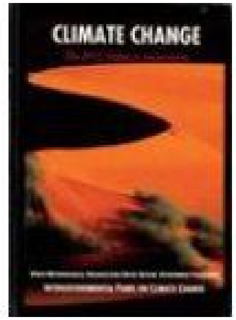


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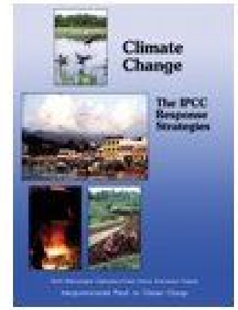


Working Group III:
The IPCC Response Strategies
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First Assessment Report
Overview Chapter (PDF)
Also in: Chinese - French - Russian - Spanish

### 1.0.1 *We are certain of the following:*

- There is a natural greenhouse effect which already keeps the Earth warmer than it would otherwise be.

- Emissions resulting from human activities are substantially increasing the atmospheric concentrations of the greenhouse gases: carbon dioxide, methane, chlorofluorocarbons (CFCs) and nitrous oxide. These increases will enhance the greenhouse effect, resulting on average in an additional warming of the Earth's surface. The main greenhouse gas, water vapour, will increase in response to global warming and further enhance it.

### 1.0.3 ***Based on current model results, we predict:***

- An average rate of increase of global mean temperature during the next century of about 0.3°C per decade (with an uncertainty range of 0.2—0.5°C per decade) assuming the IPCC Scenario A (Business-as-Usual) emissions of greenhouse gases; this is a more rapid increase than seen over the past 10,000 years. This will result in a likely increase in the global mean temperature of about 1°C above the present value by 2025 (about 2°C above that in the pre-industrial period), and 3°C above today's value before the end of the next century (about 4°C above pre-industrial). The

# 2. Impacts

2.0.1 The report on impacts of Working Group II is based on the work of a number of subgroups, using independent studies which have used different methodologies. Based on the existing literature, the studies have used several scenarios to assess the potential impacts of climate change. These have the features of:

i) an effective doubling of $CO_2$ in the atmosphere between now and 2025 to 2050;

ii) a consequent increase of global mean temperature in the range of 1.5°C to 4.5°C;

iii) an unequal global distribution of this temperature increase, namely a smaller increase of half the global mean in the tropical regions and a larger increase of twice the global mean in the polar regions;

iv) a sea-level rise of about 0.3—0.5 m by 2050 and about 1 m by 2100, together with a rise in the temperature of

## 1992 Supplementary Reports

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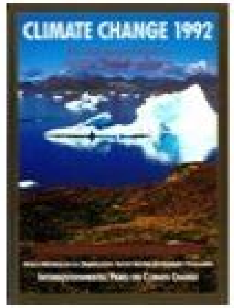


The Supplementary Report to
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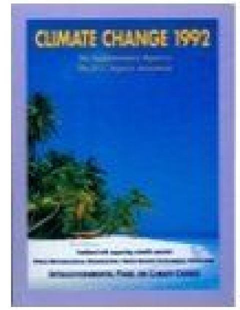


The Supplementary Report to
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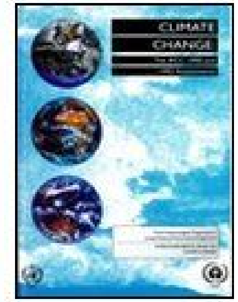


The IPCC 1990 and
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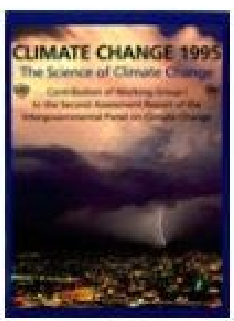
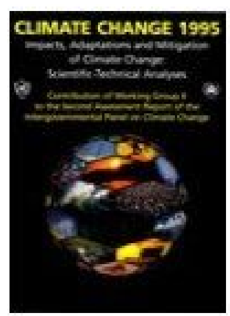
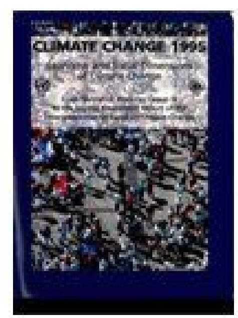



Working Group I:
The Science of Climate Change
Full Report (PDF)




Working Group II:
Impacts, Adaptations and
Mitigation of Climate Change:
Scientific-Technical Analyses
Full Report (PDF)

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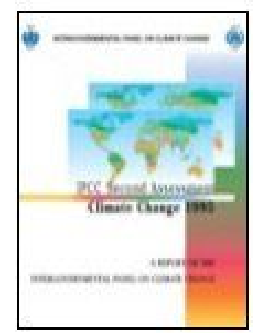
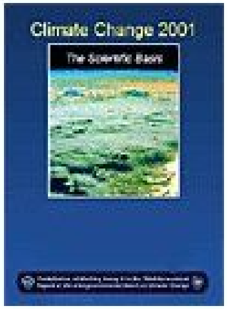
Economic and Social
Dimensions of Climate Change
Full Report (PDF)



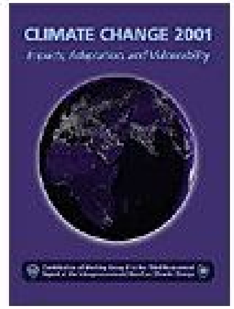

IPCC Second Assessment
Full Report (PDF)
Errata

Arabic - Chinese - French-
Russian - Spanish

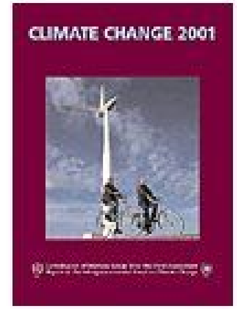
# IPCC Third Assessment Report: Climate Change 2001 (TAR)



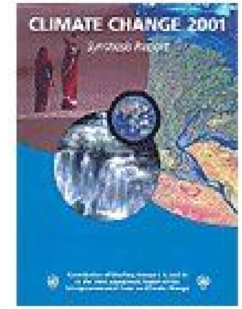

Working Group I:
The Scientific Basis




Working Group II:
Impacts, Adaptation and Vulnerability




Working Group III:
Mitigation




Synthesis Report

## WG1 - Summary for Policymakers

The Third Assessment Report of Working Group I of the Intergovernmental Panel on Climate Change (IPCC) builds upon past assessments and incorporates new results from the past five years of research on climate change[1]. Many hundreds of scientists[2] from many countries participated in its preparation and review.

This Summary for Policymakers (SPM), which was approved by IPCC member governments in Shanghai in January 2001[3], describes the current state of understanding of the climate system and provides estimates of its projected future evolution and their uncertainties. Further details can be found in the underlying report, and the appended Source Information provides cross references to the report's chapters.

### *An increasing body of observations gives a collective picture of a warming world and other changes in the climate system.*

Since the release of the Second Assessment Report (SAR[4]), additional data from new studies of current and palaeoclimates, improved analysis of data sets, more rigorous evaluation of their quality, and comparisons among data from different sources have led to greater understanding of climate change.

### *The global average surface temperature has increased over the 20th century by about 0.6°C.*

- The global average surface temperature (the average of near surface air temperature over land, and sea surface temperature) has increased since 1861. Over the 20th century the increase has been 0.6 ± 0.2°C[5], [6] (Figure 1a). This value is about 0.15°C larger than that estimated by the SAR for the period up to 1994, owing to the relatively high temperatures of the additional years (1995 to 2000) and improved methods of processing the data. These numbers take into account various adjustments, including urban heat island effects. The record shows a great deal of variability; for example, most of the warming occurred during the 20th century, during two periods, 1910 to 1945 and 1976 to 2000.
- Globally, it is very likely[7] that the 1990s was the warmest decade and 1998 the warmest year in the instrumental record, since 1861 (see Figure 1a).
- New analyses of proxy data for the Northern Hemisphere indicate that the increase in temperature in the 20th century is likely[7] to have been the largest of any century during the past 1,000 years. It is also likely[7] that, in the Northern Hemisphere, the 1990s was the warmest decade and 1998 the warmest year (Figure 1b). Because less data are available, less is known about annual averages prior to 1,000 years before present and for conditions prevailing in most of the Southern Hemisphere prior to 1861.
- On average, between 1950 and 1993, night-time daily minimum air temperatures over land increased by about 0.2°C per decade. This is about twice the rate of increase in daytime daily maximum air temperatures (0.1°C per decade). This has lengthened the freeze-free season in many mid- and high latitude regions. The increase in sea surface temperature over this period is about half that of the mean land surface air temperature.

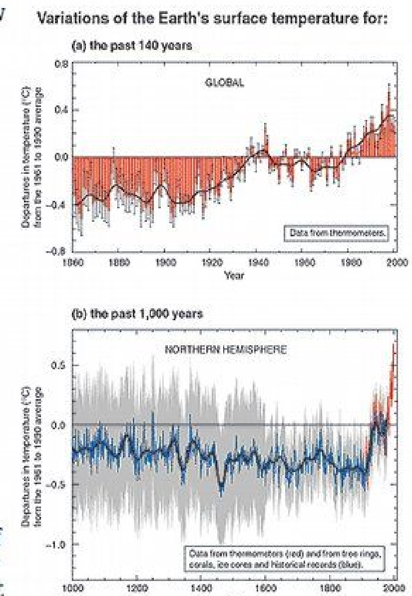
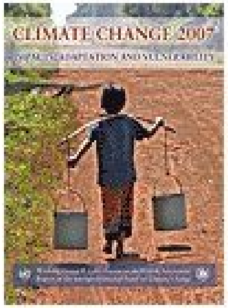



*Figure 1: Variations of the Earth's surface temperature over the last 140 years and the last millennium.*

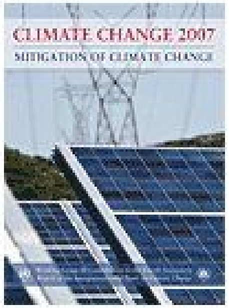
*(a) The Earth's surface temperature is shown year by year (red bars) and approximately decade by decade (black line, a filtered annual curve suppressing fluctuations below near decadal*

## IPCC Fourth Assessment Report: Climate Change 2007 (AR4)

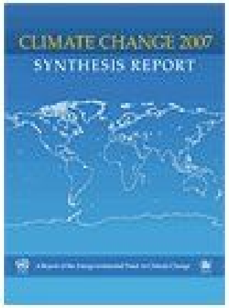

Working Group I Report
"The Physical Science Basis"




Working Group II Report
"Impacts, Adaptation and Vulnerability"



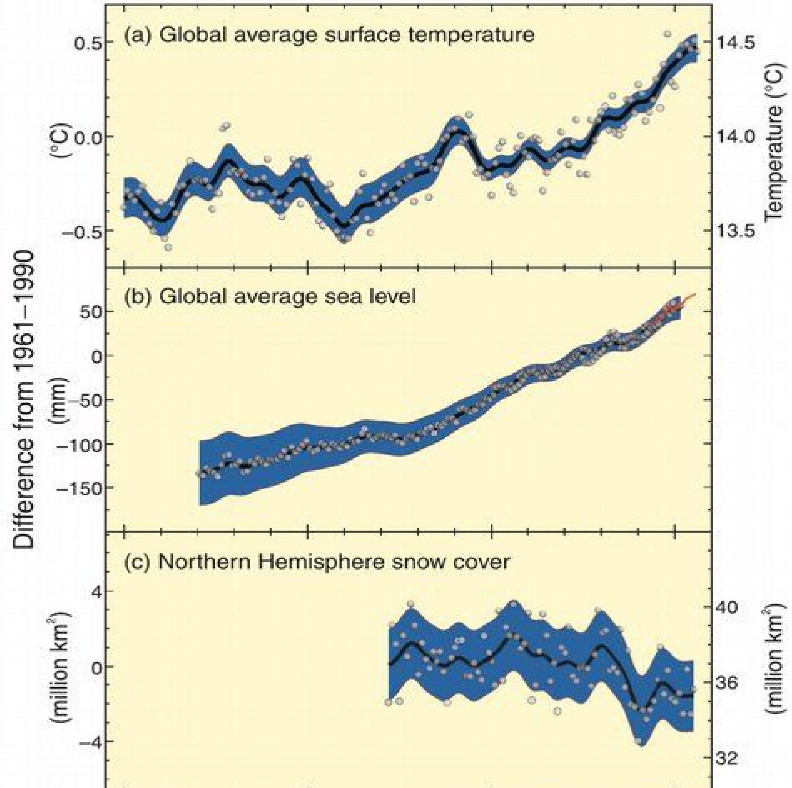

Working Group III Report
"Mitigation of Climate Change"




The AR4 Synthesis Report

# 1. Observed changes in climate and their effects

**Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level (Figure SPM.1).** *{1.1}*



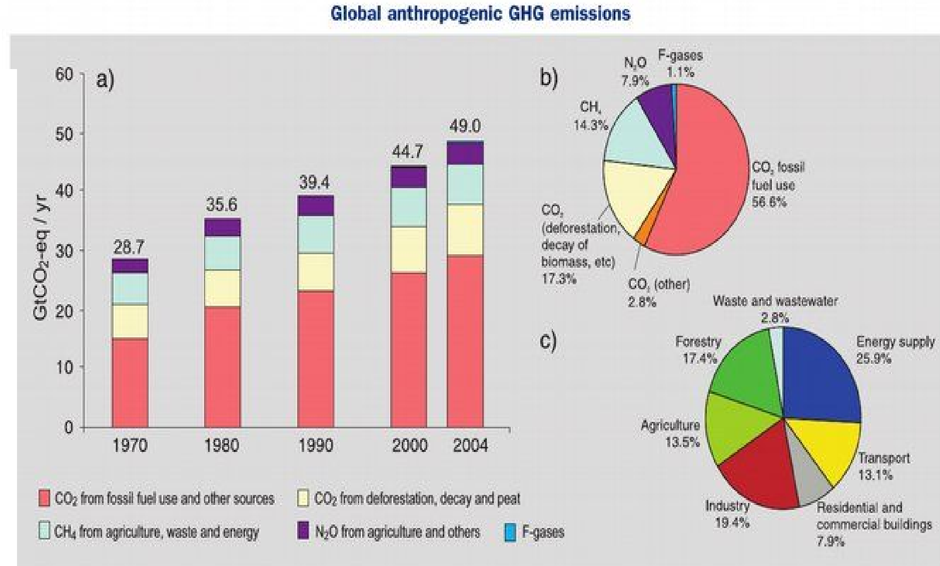
## 2. Causes of change

Changes in atmospheric concentrations of greenhouse gases (GHGs) and aerosols, land cover and solar radiation alter the energy balance of the climate system. {2.2}

**Global GHG emissions due to human activities have grown since pre-industrial times, with an increase of 70% between 1970 and 2004 (Figure SPM.3).[5] *{2.1}***

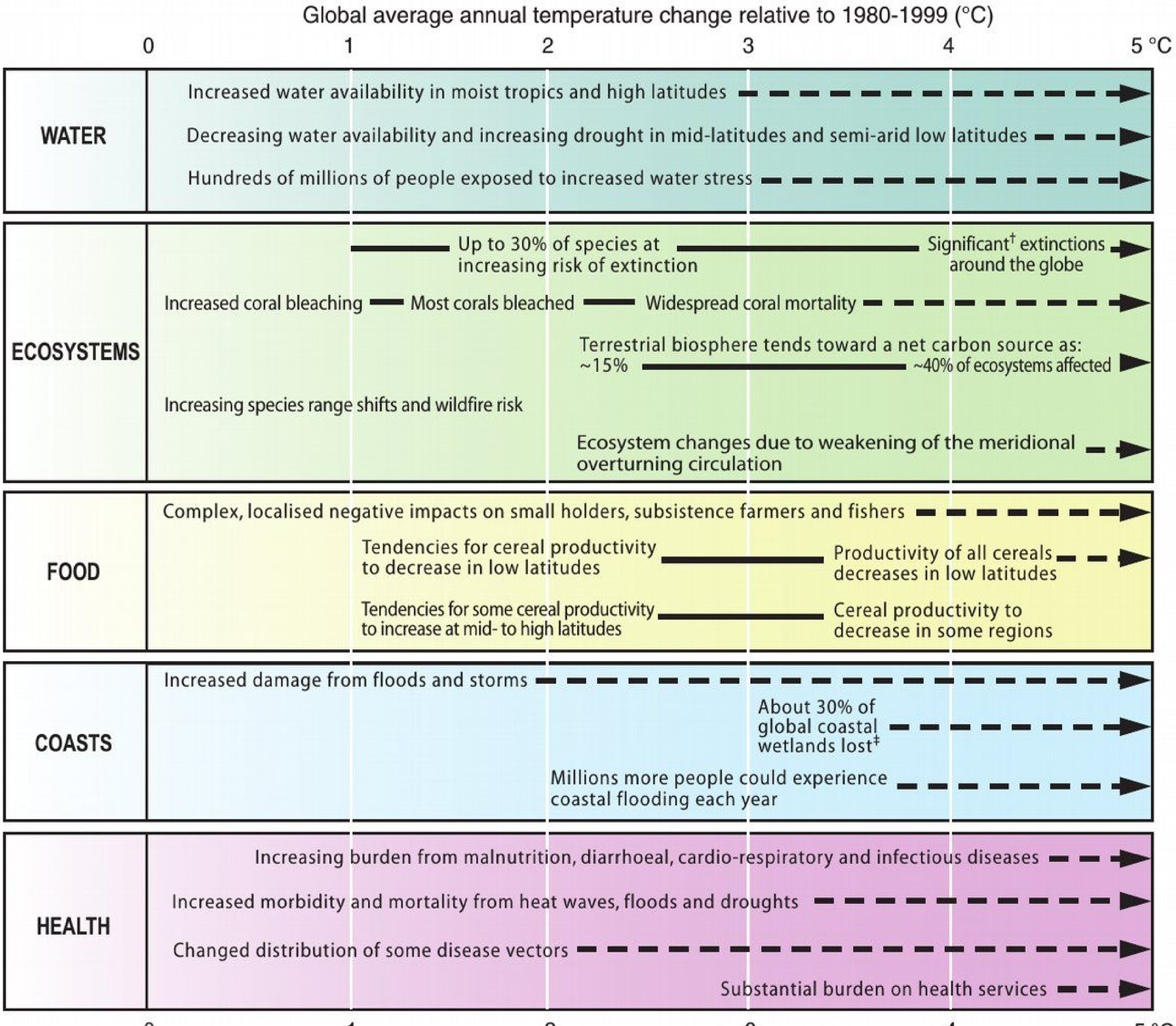
Carbon dioxide ($CO_2$) is the most important anthropogenic GHG. Its annual emissions grew by about 80% between 1970 and 2004. The long-term trend of declining $CO_2$ emissions per unit of energy supplied reversed after 2000. *{2.1}*

**Global atmospheric concentrations of $CO_2$, methane ($CH_4$) and nitrous oxide ($N_2O$) have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years. *{2.2}***

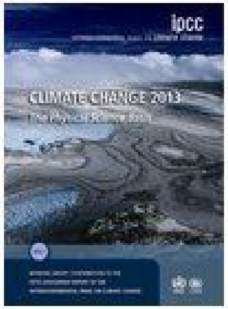



*ure SPM.3. (a) Global annual emissions of anthropogenic GHGs from 1970 to 2004.[5] (b) Share of different anthropogenic GHGs in total issions in 2004 in terms of carbon dioxide equivalents ($CO_2$-eq). (c) Share of different sectors in total anthropogenic GHG emissions in 2004 erms of $CO_2$-eq. (Forestry includes deforestation.) {Figure 2.1}*

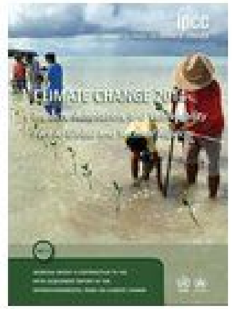
**Examples of impacts associated with global average temperature change (Impacts will vary by extent of adaptation, rate of temperature change and socio-economic pathway)**



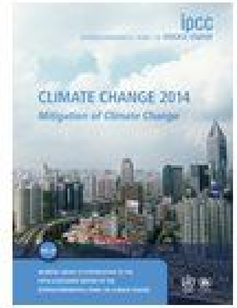
## IPCC Fifth Assessment Report




Working Group I Report
"Climate Change 2013: The Physical Science Basis"




Working Group II Report
"Climate Change 2014: Impacts, Adaptation, and

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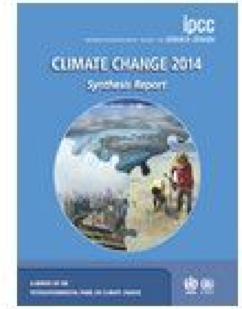


"Climate Change 2014: Synthesis Report"

# SPM 1. Observed Changes and their Causes

**Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems.** *{1}*

## SPM 1.1 Observed changes in the climate system

**Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen.** *{1.1}*

## SPM 1.2 Causes of climate change

**Anthropogenic greenhouse gas emissions have increased since the pre-industrial era, driven largely by economic and population growth, and are now higher than ever. This has led to atmospheric concentrations of carbon dioxide, methane and nitrous oxide that are unprecedented in at least the last 800,000 years. Their effects, together with those of other anthropogenic drivers, have been detected throughout the climate system and are *extremely likely* to have been the dominant cause of the observed warming since the mid-20th century.** *{1.2, 1.3.1}*

## SPM 1.3 Impacts of climate change

**In recent decades, changes in climate have caused impacts on natural and human systems on all continents and across the oceans. Impacts are due to observed climate change, irrespective of its cause, indicating the sensitivity of natural and human systems to changing climate.** *{1.3.2}*

## SPM 1.4 Extreme events

**Changes in many extreme weather and climate events have been observed since about 1950. Some of these changes have been linked to human influences, including a decrease in cold temperature extremes, an increase in warm temperature extremes, an increase in extreme high sea levels and an increase in the number of heavy precipitation events in a number of regions.** *{1.4}*

# SPM 2. Future Climate Changes, Risks and Impacts

**Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems. Limiting climate change would require substantial and sustained reductions in greenhouse gas emissions which, together with adaptation, can limit climate change risks.** *{2}*

## SPM 2.1 Key drivers of future climate

**Cumulative emissions of $CO_2$ largely determine global mean surface warming by the late 21st century and beyond. Projections of greenhouse gas emissions vary over a wide range, depending on both socio-economic development and climate policy.** *{2.1}*

## SPM 2.2 Projected changes in the climate system

**Surface temperature is projected to rise over the 21st century under all assessed emission scenarios. It is *very likely* that heat waves will occur more often and last longer, and that extreme precipitation events will become more intense and frequent in many regions. The ocean will continue to warm and acidify, and global mean sea level to rise.** *{2.2}*

## SPM 2.3 Future risks and impacts caused by a changing climate

**Climate change will amplify existing risks and create new risks for natural and human systems. Risks are unevenly distributed and are generally greater for disadvantaged people and communities in countries at all levels of development.** *{2.3}*

## SPM 2.4 Climate change beyond 2100, irreversibility and abrupt changes

**Many aspects of climate change and associated impacts will continue for centuries, even if anthropogenic emissions of greenhouse gases are stopped. The risks of abrupt or irreversible changes increase as the magnitude of the warming increases.** *{2.4}*

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# Climate Data Online

Climate Data Online (CDO) provides free access to NCDC's archive of global historical weather and climate data in addition to station history information. These data include quality controlled daily, monthly, seasonal, and yearly measurements of temperature, precipitation, wind, and degree days as well as radar data and 30-year Climate Normals. Customers can also order most of these data as certified hard copies for legal use.

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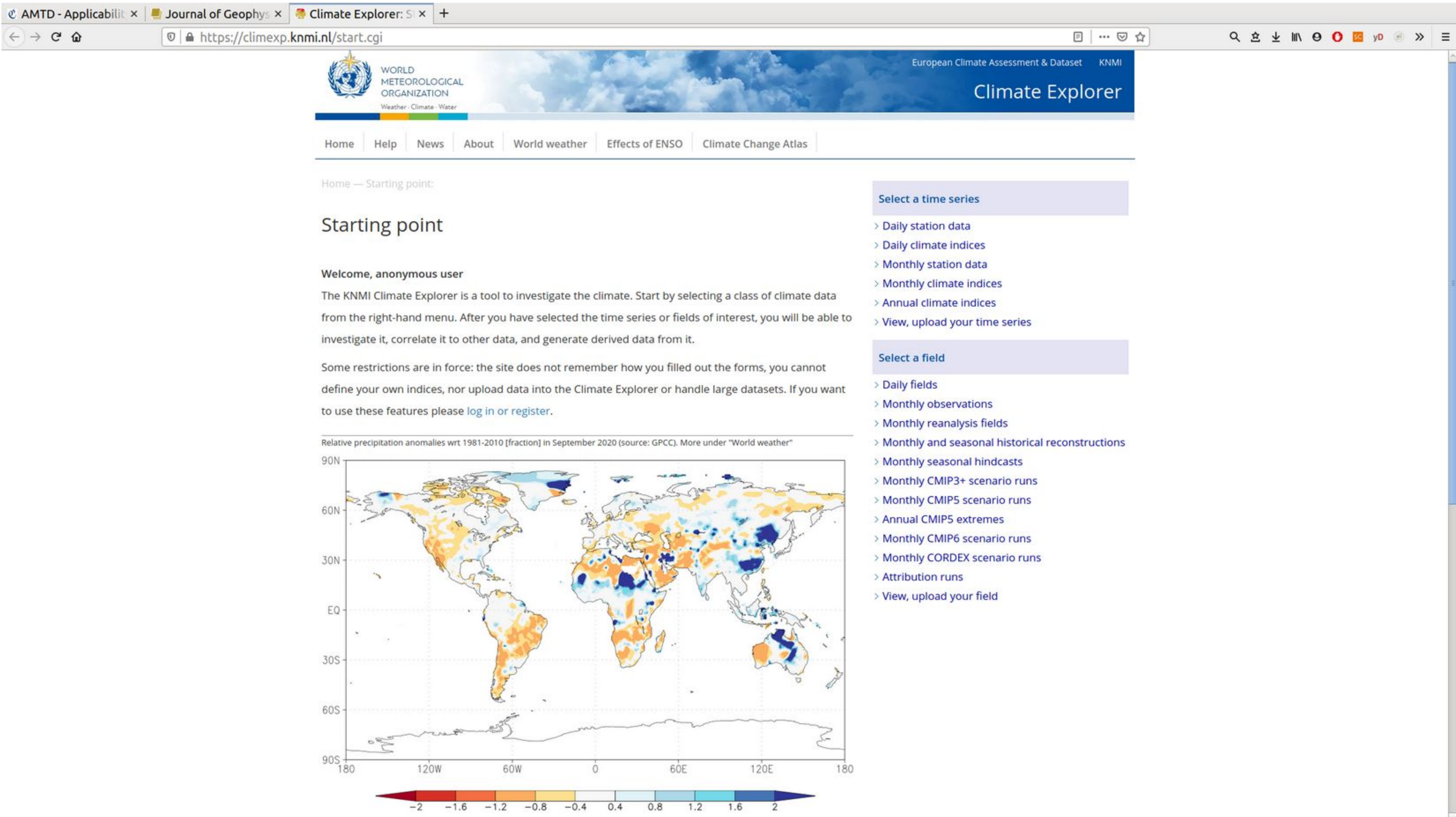
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KNMI
Climate Explorer
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Help
News
About
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Climate Change Atlas
Home — Starting point:
Starting point
Welcome, anonymous user
The KNMI Climate Explorer is a tool to investigate the climate. Start by selecting a class of climate data from the right-hand menu. After you have selected the time series or fields of interest, you will be able to investigate it, correlate it to other data, and generate derived data from it.
Some restrictions are in force: the site does not remember how you filled out the forms, you cannot define your own indices, nor upload data into the Climate Explorer or handle large datasets. If you want to use these features please log in or register.
Relative precipitation anomalies wrt 1981-2010 [fraction] in September 2020 (source: GPCC). More under "World weather"
90N
60N
30N
EQ
30S
60S
90S
180
120W
60W
0
60E
120E
180
−2
−1.6
−1.2
−0.8
−0.4
0.4
0.8
1.2
1.6
2
Select a time series
Daily station data
Daily climate indices
Monthly station data
Monthly climate indices
Annual climate indices
View, upload your time series
Select a field
Daily fields
Monthly observations
Monthly reanalysis fields
Monthly and seasonal historical reconstructions
Monthly seasonal hindcasts
Monthly CMIP3+ scenario runs
Monthly CMIP5 scenario runs
Annual CMIP5 extremes
Monthly CMIP6 scenario runs
Monthly CORDEX scenario runs
Attribution runs
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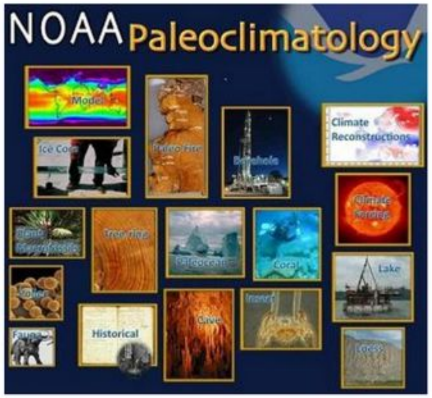
# Paleoclimatology Data

Paleoclimatology data are derived from natural sources such as tree rings, ice cores, corals, and ocean and lake sediments. These proxy climate data extend the archive of weather and climate information hundreds to millions of years. The data include geophysical or biological measurement time series and some reconstructed climate variables such as temperature and precipitation.



Paleoclimatology data are derived from a wide variety of natural sources such as tree rings, ice cores, corals, and ocean and lake sediments.

NCEI provides the paleoclimatology data and information scientists need to understand natural climate variability and future climate change. We also operate the World Data Service for Paleoclimatology, which archives and distributes data contributed by scientists around the world.

- **Paleoclimatology Datasets**
  Access paleoclimatology datasets by proxy data type
- **Paleoclimatology Data Search**
  Search all paleoclimatology datasets and analyses available from NCEI and the World Data Service for Paleoclimatology
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- **Contribute Paleoclimatology Data**
  Preserve your paleoclimatology data and make it available to others without restriction

CAM-EULAG: A non-hydrostatic atmospheric climate model with grid stretching

Babatunde J. Abiodun, William J. Gutowski, Abayomi A. Abatan, Joseph M. Prusa

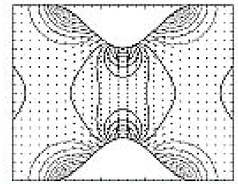
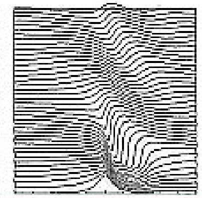
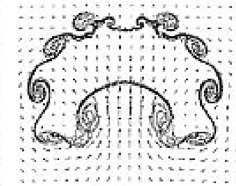
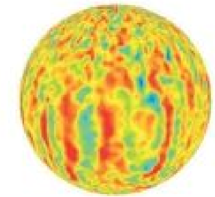
Acta Geophysica
01/2011; 59(6):1158-1167.
DOI:10.2478/s11600-011-0032-2

ABSTRACT This study evaluates the capability of a non-hydrostatic global climate model with grid stretching (CEU) that uses NCAR Community Atmospheric Model (CAM) physics and EULAG dynamics.



# Eulag

Research Model
for Geophysical Flows



FRONTIERS IN COMPUTATIONAL PHYSICS

MODELING THE EARTH SYSTEM

16-20 Dec. 2012
Boulder, CO, USA

EULAG is a numerical solver for all-scale geophysical flows. The underlying anelastic equations are either solved in an EULerian (flux form), or a LAGrangian (advective form) framework.

EULAG model is an ideal tool to perform numerical experiments in a virtual laboratory with time-dependent adaptive meshes and within complex, and even time-dependent model geometries. These abilities are due to the unique model design that combines the nonoscillatory forward-in-time (NFT) numerical algorithms and a robust elliptic solver with generalized coordinates. The code is written as a research tool with numerous options controlling the numerical accuracy and to allow for a wide range of numerical sensitivity tests. These capabilities give the researcher confidence in the numerical solutions of his/her problem. The formulation of the model equations allow for various derivatives of the code including codes for stellar atmospheres, ocean currents, sand dune propagation or biomechanical flows. EULAG is a fully parallelized code and is easily portable between different platforms.

All the model developments and details of the numerical algorithms are documented in a number of peer reviewed papers by Piotr Smolarkiewicz and his colleagues. The EULAG modeling system is developed and supported by the Cloud Systems Group in the Mesoscale and Microscale Meteorology Division, NCAR.

**Example: QBO analogue simulation**

## Current announcements:

**4th International EULAG Workshop** on Forward-in-time Differencing for Earth-System Models, 20-24 October 2014 in Mainz, Germany
(see also first announcement in PDF)

## Past events:

**3rd International EULAG Workshop** held 25th -28th June 2012 in Loughborough UK.

**2nd EULAG Model Users' Workshop** took place in Sopot, Poland, 13-16 September 2010.

**1st EULAG Model Users' Workshop** was held in Bad T�lz, Germany 6-10 October 2008. The workshop offered tutorials covering essential physical, mathematical and numerical aspects of EULAG and provided a forum to exchange information and ideas among EULAG users.

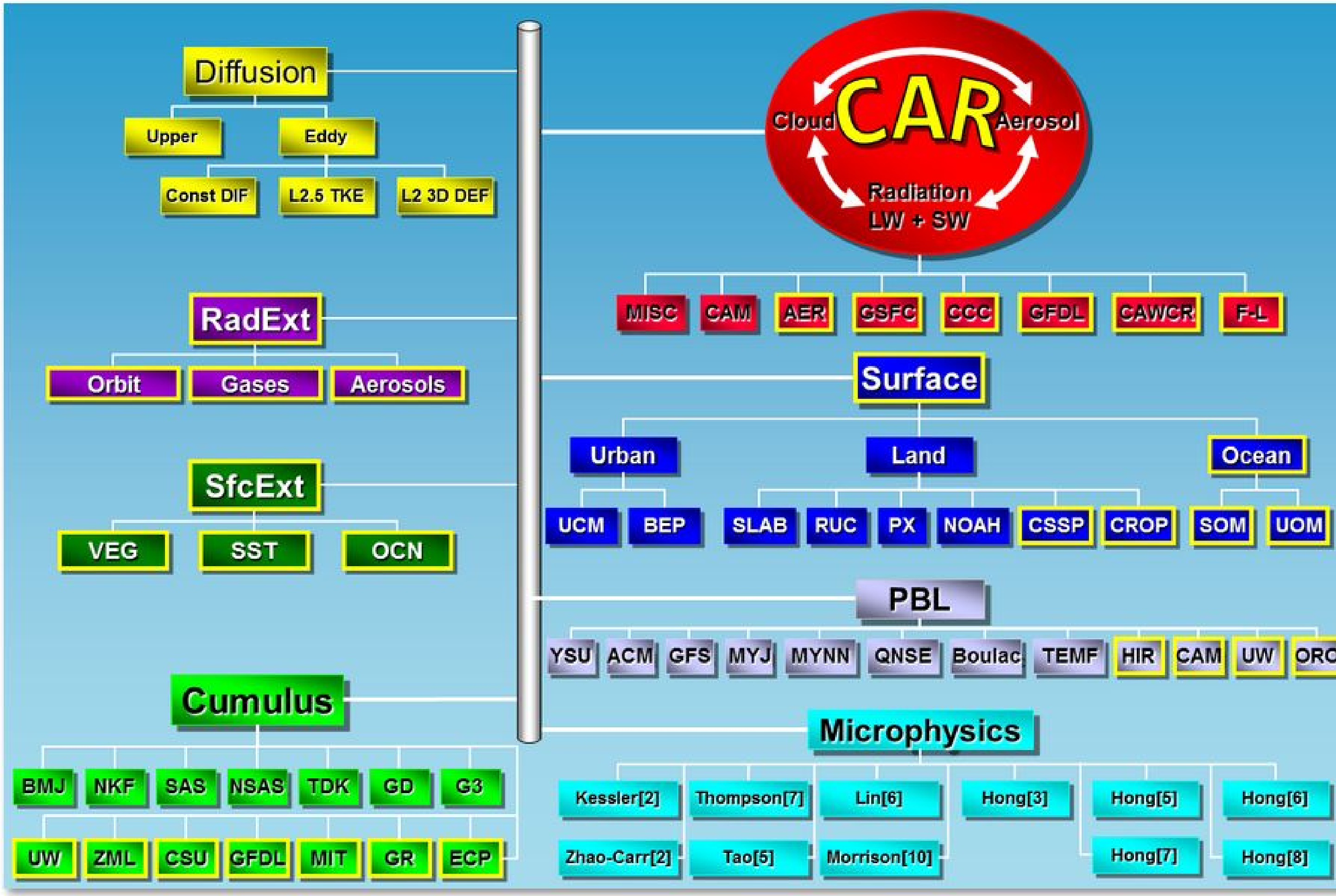
## Special issues:

The special issue of the **Acta Geophysica**: **Special volume 59 (6), 2011: Modeling Atmospheric Circulations with Sound-Proof Equations** The papers collected in the present volume of Acta Geophysica address the capability of sound-proof equations to model all-scale atmospheric circulations. Technical topics covered in this special issue range from theoretical numerical analysis, model design, and massively-parallel programming to simulation of cloud processes, regional weather and global atmospheric circulations.

CWRF

# Climate - Weather Research and Forecasting Model

Home | Developer | Physics | Forcing | Performance | Application | Prediction | Users | Publication




- CWRF is a Climate extension of the Weather Research and Forecasting model (WRF):
  - Inherits all WRF functionalities for NWP while enhancing the capability to predict climate, thus has unified applications for both weather forecast and climate prediction.
- CWRF incorporates a grand ensemble of alternative physics schemes:
  - Contains more than $10^{24}$ of alternative physics configurations representing interactions between surface

## News:

- CWRF test data available for download
- CWRF website goes live
- CWRF V3.1.1 ready to release

## Links:

- CAR: Cloud-Aerosol-Radiation Ensemble Modeling System
- WRF: The Weather Research and Forecasting Model
- ESSIC/UMD

NCAR
UCAR
CESM
COMMUNITY EARTH SYSTEM MODEL

*earth • modeling • climate*

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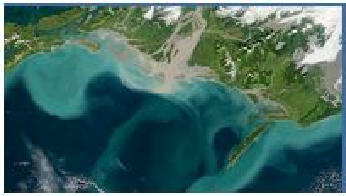
## 19TH ANNUAL CESM WORKSHOP

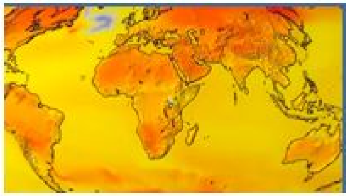
16 - 19 June 2014

### CESM EXPERIMENTS



- CESM Experiments
- CMIP5 Output
- IPCC Experiments

### CESM RELEASES



- CESM Supported Releases
- CESM Scientifically Validated Configurations
- CESM Legacy Models

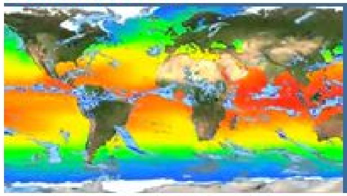
### ANNOUNCEMENTS & EVENTS

- 19th Annual CESM Workshop, 16-19 June 2014, Breckenridge, CO
- CESM Tutorial, 11-15 August 2014, Boulder, CO

### CESM GOVERNANCE

### CESM PROJECTS

### CESM SUPPORT



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EdGCM Educational Global Climate Modeling

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- The People
- Climate News and Information

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- EdGCM 4D
- Scientific Visualization
- Other Utilities

**Community**
- Showcase
- Simulation Library
- Partnerships

**Support**
- FAQ
- Documentation
- Forums

# Software update

ANNOUNCEMENTS:
EdGCM 4.0 beta is now available for Mac OS X Lion (10.7) and Mountain Lion (10.8) read more…
EdGCM 3.2 users: Windows 7 and Mac OS X 10.6 (Snow Leopard) updates are still available read more…

EdGCM provides a research-grade Global Climate Model (GCM) with a user-friendly interface that can be run on a desktop computer. For the first time, students can explore the subject of climate change in the same way that actual research scientists do. In the process of using EdGCM, students will become knowledgeable about a topic that will surely affect their lives, and we will better prepare the next generation of scientists who will grapple with a myriad of complex climate issues.

Our goal is to improve the quality of teaching and learning of climate-change science through broader access to GCMs, and to provide appropriate technology and materials to help educators use these models effectively. With research-quality resources in place, linking classrooms to actual research projects is not only possible, but can also be beneficial to the education and research communities alike.

Read more…

CMIP - Overview - Mozilla Firefox

Plik Edycja Widok Historia Zakładki Narzędzia Pomoc

http://pcmdi-cmip.llnl.gov/index.html?submenuheader=0

cmip climate

CMIP - Overview



Denmark Norway Japan United Kingdom Italy Russia S. Korea Germany France The Netherlands China Canada USA Australia

# CMIP Coupled Model Intercomparison Project

WCRP World Climate Research Programme

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## CMIP - Coupled Model Intercomparison Project - Overview

Under the World Climate Research Programme (WCRP) the Working Group on Cloupled Modelling (WGCM) established the Coupled Model Intercomparison Project (CMIP) as a standard experimental protocol for studying the output of coupled atmosphere-ocean general circulation models (AOGCMs). CMIP provides a community-based infrastructure in support of climate model diagnosis, validation, intercomparison, documentation and data access. This framework enables a diverse community of scientists to analyze GCMs in a systematic fashion, a process which serves to facilitate model improvement. Virtually the entire international climate modeling community has participated in this project since its inception in 1995. The Program for Climate Model Diagnosis and Intercomparison (PCMDI) archives much of the CMIP data and provides other support for CMIP. PCMDI's CMIP effort is funded by the Regional and Global Climate Modeling (RGCM) Program of the Climate and Environmental Sciences Division of the U.S. Department of Energy's Office of Science, Biological and Environmental Research (BER) program.

Coupled atmosphere-ocean general circulation models allow the simulated climate to adjust to changes in climate forcing, such as increasing atmospheric carbon dioxide. CMIP began in 1995 by collecting output from model "control runs" in which climate forcing is held constant. Later versions of CMIP have collected output from an idealized scenario of global warming, with atmospheric CO2 increasing at the rate of 1% per year until it doubles at about Year 70. CMIP output is available for study by approved diagnostic sub-projects.

Phase three of CMIP (CMIP3) included "realistic" scenarios for both past and present climate forcing. The research based on this dataset provided much of the new material underlying the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4).

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## Current Intercomparison - CMIP5

We are now beginning the process towards the IPCC Fifth Assessment Report and with it the CMIP5 intercomparison activity.
The CMIP5 (CMIP Phase 5) experiment design has been finalized with the following suites of experiments:

I Decadal Hindcasts and Predictions simulations,
II "long-term" simulations,
III "atmosphere-only" (prescribed SST) simulations for especially computationally-demanding models.

Zakończono

# CMIP Phase 6 (CMIP6)

## Overview CMIP6 Experimental Design and Organization

The overview paper on the CMIP6 experimental design and organization has now been published in GMD (Eyring et al., 2016). This CMIP6 overview paper presents the background and rationale for the new structure of CMIP, provides a detailed description of the CMIP Diagnostic, Evaluation and Characterization of Klima (DECK) experiments and CMIP6 historical simulations, and includes a brief introduction to the 23 CMIP6-Endorsed MIPs.

A brief summary can be found in the following overview presentation (CMIP6FinalDesign_GMD_180329.pdf) and below. After a long and wide community consultation, a new and more federated structure has been put in place. It consists of three major elements:

1. a handful of common experiments, the DECK (Diagnostic, Evaluation and Characterization of Klima) and CMIP historical simulations (1850 – near-present) that will maintain continuity and help document basic characteristics of models across different phases of CMIP,
2. common standards, coordination, infrastructure and documentation that will facilitate the distribution of model outputs and the characterization of the model ensemble, and
3. an ensemble of CMIP-Endorsed Model Intercomparison Projects (MIPs) that will be specific to a particular phase of CMIP (now CMIP6) and that will build on the DECK and CMIP historical simulations to address a large range of specific questions and fill the scientific gaps of the previous CMIP phases.

### WGCM

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- Meetings
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- CMIP
  - A Short Introduction (Video)
  - CMIP Panel
  - CMIP3
  - CMIP5
  - CMIP6
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  - CMIP6-Endorsed MIPs
  - Other active MIPs
  - Former MIPs
- Sessions

Modelling Overview

Almost everything important is just a mouse click away, open, ready for criticism!