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Findings of the IPCC Fourth Assessment Report

Climate Change Science

After assessing decades of climate data recorded everywhere from the depths of the oceans to tens of miles above Earth's surface, leading scientists from around the world have reported major advances in our understanding of climate change.

Released in February 2007—six years after the prior assessment by the Intergovernmental Panel on Climate Change (IPCC)—the IPCC Fourth Assessment Report's Working Group I Summary for Policymakers synthesizes current scientific understanding of global warming and projects future climate change using the most comprehensive set of well-established global climate models.[1] The Working Group I contribution is the first of three that comprise the full IPCC Fourth Assessment Report, which includes the input of more than 1,200 authors and 2,500 scientific expert reviewers from more than 130 countries. In subsequent reports, Working Group II evaluates "Impacts, Adaptation and Vulnerability" and Working Group III evaluates "Mitigation of Climate Change."[2]

What the IPCC Means by "Likely"

When the IPCC ascribes a likelihood to a scientific finding, the term used reflects a specific range of certainty as defined by the chart below.

Human Responsibility for Climate Change

The report finds that it is "very likely" that emissions of heat-trapping gases from human activities have caused "most of the observed increase in globally averaged temperatures since the mid-20th century." Evidence that human activities are the major cause of recent climate change is even stronger than in prior assessments.[3]

Warming Is Unequivocal

The report concludes that it is "unequivocal" that Earth's climate is warming, "as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level."

The report also confirms that the current atmospheric concentration of carbon dioxide and methane, two important heat-trapping gases, "exceeds by far the natural range over the last 650,000 years." Since the dawn of the industrial era, concentrations of both gases have increased at a rate that is "very likely to have been unprecedented in more than 10,000 years."

Additional IPCC Findings on Recent Climate Change

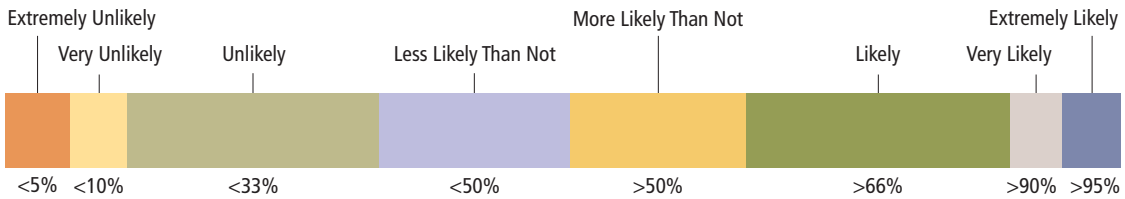
Rising Temperatures

- Eleven of the last 12 years rank among the 12 hottest years on record (since 1850, when sufficient worldwide temperature measurements began).
- Over the last 50 years, "cold days, cold nights, and frost have become less frequent, while hot days, hot nights, and heat waves have become more frequent."

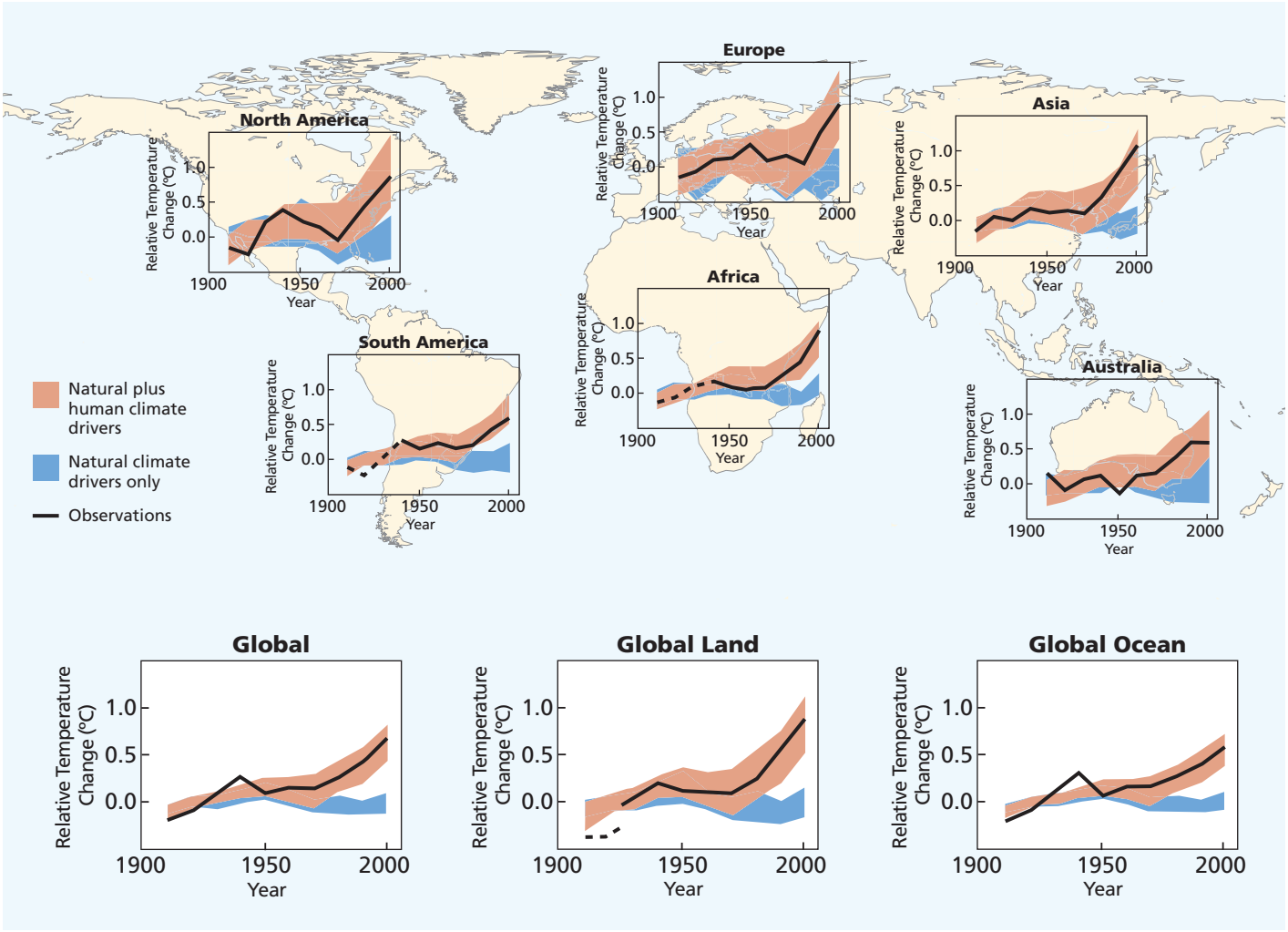
Increasingly Severe Weather (storms, precipitation, drought)

- The intensity of tropical cyclones (hurricanes) in the North Atlantic has increased over the past 30 years, which correlates with increases in tropical sea surface temperatures.
- Storms with heavy precipitation have increased in frequency over most land areas. Between 1900 and 2005, long-term trends show significantly increased precipitation in eastern parts of North and South America, northern Europe, and northern and central Asia.

IPCC Range of Likelihood



Global and Continental Temperature Change



The **black line** represents observed surface temperature changes for the globe and each continent (based on temperatures recorded by measuring stations around the world). The **blue band** represents how the climate would have evolved over the past century in response to natural factors only (according to 19 computer simulations derived from five different climate models); the **brown band** represents how the climate would have changed in response to both human and natural factors (according to 58 computer simulations derived from 14 different climate models). The overlap of the brown band and black line suggests that human activity very likely caused most of the observed increase since the mid-20th century. Temperature change is plotted relative to the corresponding average for the 1901 to 1950 time period. Source: *Climate Change 2007: The Physical Science Basis*—Summary for Policymakers.

- Between 1900 and 2005, the Sahel (the boundary zone between the Sahara desert and more fertile regions of Africa to the south), the Mediterranean, southern Africa, and parts of southern Asia have become drier, adding stress to water resources in these regions.
- Droughts have become longer and more intense, and have affected larger areas since the 1970s, especially in the tropics and subtropics.

Melting and Thawing

- Since 1900 the Northern Hemisphere has lost seven percent of the maximum area covered by seasonally frozen ground.
- Mountain glaciers and snow cover have declined worldwide.
- Satellite data since 1978 show that the extent of Arctic sea ice during the summer has shrunk by more than 20 percent.

Rising Sea Levels

- Since 1961, the world's oceans have been absorbing more than 80 percent of the heat added to the climate, causing ocean water to expand and contributing to rising sea levels. Between 1993 and 2003 ocean expansion was the largest contributor to sea-level rise.
- Melting glaciers and losses from the Greenland and Antarctic ice sheets have also contributed to recent sea-level rise.

Refined Projections of Climate Change

Projected climate change for the second half of this century depends on the level of future heat-trapping emissions. The IPCC based its projections on six emission scenarios, running each one through sophisticated climate simulation programs.

The lowest temperatures currently

projected for the end of this century represent the lowest scenario the IPPC chose to evaluate—the "B1" scenario (see table below), which assumes a mid-century peak in global population, a rapid change toward a service and information economy, and a shift toward clean and resource-efficient technologies. The highest temperatures projected for the end of this century represent the highest scenario the IPPC chose to evaluate—the "A1FI" scenario, which assumes a mid-century peak in global population, rapid economic growth, and "fossil-intensive" energy production and consumption.

The IPCC's prior assessment in 2001 used many more emission scenarios, so projections of temperature changes, sea-level rise, etc. in that report are not directly comparable with those in the new assessment. Nevertheless, both assessments have shown that the degree of climate change in the decades ahead strongly depends on the emission scenario. The IPCC's findings are therefore crucial to informing climate policy.

Even if we act today to reduce our emissions from cars, power plants, land use, and other sources, we will see some degree of continued warming because past emissions will stay in the atmosphere for decades or more. If we take *no* action to reduce emissions, the IPCC concludes that there will be twice as much warming over the next two decades than if we had stabilized heat-trapping gases and other climate-relevant pollutants in the atmosphere at their year 2000 levels.

Additional IPCC Findings on Future Climate Change

Rising Temperatures[4]

- The **full range** of projected temperature increase is 2 to 11.5 degrees Fahrenheit (1.1 to 6.4 degrees Celsius) by the end of the century. Note that the upper end of the range is higher than the prior IPCC assessment, mainly because of increased understanding that "warming tends to reduce land and ocean uptake of atmospheric carbon dioxide, increasing the fraction of [carbon dioxide] emissions that remains in the atmosphere."
- The **best estimate range** of projected temperature increase, which extends from the midpoint of the lowest emission scenario to the midpoint of the highest, is 3.1 to 7.2 degrees Fahrenheit (1.8 to 4.0 degrees Celsius) by the end of the century.
- "Warming is expected to be greatest over land and at most high northern latitudes, and least over the Southern [formerly Antarctic] Ocean and parts of the North Atlantic Ocean."

Increasingly Severe Weather (storms, precipitation, drought)

- Tropical cyclones (hurricanes and typhoons) are likely to become more intense, with higher peak wind speeds and heavier precipitation associated with warmer tropical seas.
- Increases in the amount of high-latitude precipitation are very likely, while decreases are likely in most subtropical land regions (e.g., Egypt).
- Extreme heat, heat waves, and heavy precipitation are very likely to continue becoming more frequent.

Melting Ice

- Sea ice is projected to shrink in both the Arctic and Antarctic under all model simulations. Some projections show that by the latter part of the century, late-summer Arctic sea ice will disappear almost entirely.

Changes in the Ocean

- The IPCC uses the term meridional overturning circulation (MOC), which is also known as thermohaline circulation, to refer to ocean circulation driven by differences in water density due to heat (*thermo*) and salt (*haline*) content. The MOC is an important mechanism for bringing heat to polar regions. If it slows down this heat transfer would slow down. The

Projected Globally Averaged Surface Warming and Sea-Level Rise at the End of the 21st Century

	Temperature Change (°F at 2090–2099 relative to 1980–1999)		Sea-Level Rise (inches at 2090–2099 relative to 1980–1999)
Case	Best estimate	Likely range	Model-based range excluding future rapid dynamical changes in ice flow
Constant Year 2000 concentrations	1.1	0.5 – 1.6	NA
B1 scenario	3.2	2.0 – 5.2	7.1 – 15.0
A1T scenario	4.3	2.5 – 6.8	7.9 – 17.7
B2 scenario	4.3	2.5 – 6.8	7.9 – 16.9
A1B scenario	5.0	3.1 – 7.9	8.3 – 18.9
A2 scenario	6.1	3.6 – 9.7	9.1 – 20.1
A1FI scenario	7.2	4.3 – 11.5	10.2 – 23.2

KEY
Relative temperature change in °C is equal to °F divided by 1.8. One inch is equal to 2.54 cm. For example, The B2 Scenario has a best estimate temperature change of 2.4°C and a sea-level rise of 20 to 43 cm by 2090–2099.

Source: Climate Change 2007: The Physical Science Basis—Summary for Policymakers.

IPCC states that it is very likely that the Atlantic Ocean MOC will be 25 percent slower on average by 2100 (with a range from 0 to 50 percent). Nevertheless, Atlantic regional temperatures are projected to rise overall due to more significant warming from increases in heat-trapping emissions.

- "Increasing atmospheric carbon dioxide concentrations will lead to increasing acidification of the ocean," with negative repercussions for all shell-forming species and their ecosystems.[5]

Sea-level Rise

Compared with its prior assessment, the IPCC has used improved statistical methods for calculating several factors that contribute to global sea-level rise. These factors include:

- ocean expansion resulting from increased water temperatures;
- meltwater runoff from mountain glaciers around the world; and
- meltwater runoff and calving (breaking off) of ice from the Greenland and Antarctica ice sheets.

The models used by the IPCC project that by the end of this century, the global average sea-level will rise between 7 and 23 inches (0.18 and 0.59 meters) above the 1980–1999 average. As with temperatures described above, this range is not directly comparable to the prior IPCC assessment because of the smaller number of emission scenarios evaluated and improved statistical methods. That being said, the midpoint of the scenarios used in both assessments differed by only 10 percent between the prior assessment and the current one.

Also, if the observed contributions from the Greenland and Antarctic ice sheets between 1992 and 2003, the IPCC states, "were to grow linearly with global average temperature change," the upper ranges of sea-level rise would increase by 3.9 to 7.9 inches (0.1 to 0.2 meters). In other words, in this example, the upper range for sea-level rise would be 31 inches (0.79 meters).

Due to ongoing scientific uncertainty, the IPCC notes that the following factors

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are not fully reflected in its current sea-level rise models:

- *Carbon dioxide uptake.* Evidence suggests that warming tends to reduce land and ocean uptake of atmospheric carbon dioxide, increasing the portion of carbon dioxide emissions that remain in the atmosphere. This would result in further warming and cause additional sea-level rise.
- *Ice sheet instability.* Recent observations show that meltwater can run down cracks in the ice and lubricate the bottom of ice sheets, resulting in faster ice flow and increased movement of large ice chunks into the ocean. This process, and others related to ice flow dynamics, directly contributes to sea-level rise.

While calling attention to these processes, which could result in a significantly higher global sea-level than that projected in its new report, the IPCC is careful to alert policy makers to the limits of our current ability to quantify these mechanisms: "Larger values cannot be excluded, but understanding of these effects is too limited to assess their likelihood or provide a best estimate or an upper bound for sea-level rise."

Some models do suggest that sustained warming between 2 and 7 degrees Fahrenheit above today's global average temperature would initiate irreversible melting of the Greenland ice sheet—which could ultimately contribute about 23 *feet* to sea-level rise. This threshold is similar to the IPCC's best estimate range for temperature increase by the end of this century. The risk for crossing this threshold could occur within our generation, while the consequences would be felt by future generations.

ENDNOTES

1. Whenever practical, the exact language from the Summary for Policymakers is used throughout this document. To enhance clarity, slight modifications were made that maintain the intended meaning of the report. The Summary for Policymakers released February 2, 2007, was the first contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (the Working Group I technical report is titled *Climate Change 2007: The Physical Science Basis*). Available at *www.ipcc.ch.*
2. For more background on IPCC history and process, visit *www.ucsusa.org/global_warming/science/the-ipcc.html.*
3. The Third Assessment Report (TAR 2001) concluded that "most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentration."
4. The IPCC now displays greater confidence in the so-called equilibrium climate sensitivity test, which estimates the global average surface warming following a sustained doubling of carbon dioxide concentrations. Under this test it is likely that temperatures would increase between 3.6 and 8.1 degrees Fahrenheit (2.0 to 4.5 degrees Celsius) by the end of the century, with a best estimate of about 5.4 degrees Fahrenheit (3.0 degrees Celsius).
5. Projected "reductions in average global surface ocean pH are between 0.14 and 0.35 units over the 21st century, adding to the present decrease of 0.1 units since pre-industrial times."

This summary, drafted by B. Ekwurzel of the Union of Concerned Scientists (UCS) benefited from helpful reviews by T. Stocker (University of Bern), R.C.J. Somerville (Scripps Institution of Oceanography), S.J. Hassol (Climate Science Communicator), and P.C. Frumhoff (UCS). The information contained herein is the sole responsibility of UCS.

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Two Brattle Square, Cambridge, MA 02238-9105 • Tel (617) 547-5552
1707 H St. NW, Suite 600, Washington, DC • Tel (202) 223-6133

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