



Highlights from
Climate Change 2007
Synthesis Report of the IPCC Fourth Assessment Report
Summary for Policy Makers

On November 17, 2007, the Intergovernmental Panel on Climate Change released its Summary for Policymakers for the Synthesis Report of the IPCC Fourth Assessment Report (AR4) on climate change science. The Synthesis Report summarizes, in plain language, the main findings of the three working group reports released earlier in the year. The three working groups (WG) summarized the state of knowledge regarding the physical science of climate change (WG I); the observed and projected impacts of climate change (WG II); and the options and potential pathways for mitigating future climate change (WG III).

In order to communicate the most policy-relevant conclusions of its assessments, the IPCC's summaries for policymakers generally focus on conclusions and projections with reasonable certainty and confidence. The IPCC describes certainty based on varying levels of likelihood of an observed or projected outcome and confidence in a given conclusion as follows:

Exceptionally Unlikely (<1%)		Less Likely Than Not		More Likely Than Not		Virtually Certain (>99%)	
Very Unlikely	Unlikely				Likely	Very Likely	
<10%	<33%	<50%	>50%	>66%	>90%		



Likelihood is based on quantifiable probabilities from data or model output or, when quantitative measures are lacking, systematic survey of expert opinion within relevant fields of science. For example, *more likely than not* signifies better than 50:50 odds and *very likely* signifies greater than 9 out of 10 odds that an outcome has or will occur. In addition to the terms shown above, the IPCC uses the term *unequivocal* to signify absolute certainty about an observed outcome.

Very Low	Low	Medium	High	Very High
<10%	~20%	~50%	~80%	>90%



Confidence is based on subjective expert opinion as agreed upon by the authors involved in the assessment. For example, *medium confidence* signifies more or less even odds and *very high confidence* signifies at least a 9 out of 10 chance that a statement is correct.

The following summary of highlights is extracted directly from the draft full Summary for policymakers as it was released on November 17, 2007. Text in {brackets} summarizes the contents of tables and figures in the report. The final document may change slightly as a result of copyediting, but the substance of the document is final. The full draft document is available online at the IPCC web site: http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf.

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.

Observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases.

There is **medium confidence** that other effects of regional climate change on natural and human environments are emerging, although many are difficult to discern due to adaptation and non-climatic drivers.

2. Causes of change

Global greenhouse gas emissions due to human activities have grown since pre-industrial times, with an increase of 70% between 1970 and 2004.

- Carbon dioxide (CO₂) is the most important anthropogenic GHG. Its annual emissions grew by about 80% between 1970 and 2004. The long-term trend of declining CO₂ emissions per unit of energy supplied reversed after 2000.
- Global atmospheric concentrations of CO₂, methane (CH₄) and nitrous oxide (N₂O) 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.
- There is **very high confidence** that the net effect of human activities since 1750 has been one of warming.

Most of the observed increase in globally-averaged temperatures since the mid-20th century is **very likely** due to the observed increase in anthropogenic GHG concentrations. It is likely there has been significant anthropogenic warming over the past 50 years averaged over each continent (except Antarctica).

- During the past 50 years, the sum of solar and volcanic forcings would **likely** have produced cooling.
- Human influences have:
 - **very likely** contributed to sea level rise during the latter half of the 20th century;
 - **likely** contributed to changes in wind patterns, affecting extra-tropical storm tracks and temperature patterns;
 - **likely** increased temperatures of extreme hot nights, cold nights and cold days;
 - **more likely than not** increased risk of heat waves, area affected by drought since the 1970s and frequency of heavy precipitation events.

3. Projected climate change and its impacts

There is high agreement and much evidence that with current climate change mitigation policies and related sustainable development practices, global greenhouse gas emissions will continue to grow over the next few decades.

Continued greenhouse gas emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would **very likely** be larger than those observed during the 20th century.

- For the next two decades a warming of about 0.2°C per decade is projected for a range of SRES emissions scenarios.
- {In Table SPM.1, best estimates of global average surface temperature rise for a variety of SRES emissions scenarios range from 1.8 to 4.0 °C (3.2–7.2 °F) ca. 2095 compared to ca. 1990.}
- {In Table SPM.1, model projections for a variety of SRES emissions scenarios, projections range from 18 to 59 cm (0.6–1.9 feet) ca. 2095 compared to 1990.}

Because understanding of some important effects driving sea level rise is too limited, **this report does not assess the likelihood, nor provide a best estimate or an upper bound for sea level rise**. The projections do not include uncertainties in climate-carbon cycle feedbacks nor the full effects of changes in ice sheet flow, therefore the upper values of the ranges are not to be considered upper bounds for sea level rise.

There is now higher confidence than in the [2001 IPCC assessment report] in projected patterns of warming and other regional-scale features, including changes in wind patterns, precipitation, and some aspects of extremes and sea ice.

- warming greatest over land and at most high northern latitudes and least over Southern Ocean and parts of the North Atlantic Ocean, continuing recent observed trends in contraction of snow cover area, increases in thaw depth over most permafrost regions, and decrease in sea ice extent; in some projections... Arctic late-summer sea ice disappears almost entirely by the latter part of the 21st century;
- **very likely** increase in frequency of hot extremes, heat waves, and heavy precipitation;
- **likely** increase in tropical cyclone intensity; less confidence in global decrease of tropical cyclone numbers;
- poleward shift of extra-tropical storm tracks with consequent changes in wind, precipitation, and temperature patterns;
- **very likely** precipitation increases in high latitudes and likely decreases in most subtropical land regions, continuing observed recent trends.

There is **high confidence** that by mid-century, annual river runoff and water availability are projected to increase at high latitudes (and in some tropical wet areas) and decrease in some dry regions in the mid-latitudes and tropics. There is also **high confidence** that many semi-arid areas (e.g. Mediterranean basin, western United States, southern Africa and northeast Brazil) will suffer a decrease in water resources due to climate change.

Some systems, sectors and regions are **likely** to be especially affected by climate change.

Systems and sectors:

- particular ecosystems:

- terrestrial: tundra, boreal forest and mountain regions because of sensitivity to warming; Mediterranean-type ecosystems because of reduction in rainfall; and tropical rainforests where precipitation declines;
- coastal: mangroves and salt marshes, due to multiple stresses;
- marine: coral reefs due to multiple stresses; the sea ice biome because of sensitivity to warming;
- water resources in some dry regions at mid-latitudes¹³ and in the dry tropics, due to changes in rainfall and evapotranspiration, and in areas dependent on snow and ice melt;
- agriculture in low-latitudes, due to reduced water availability;
- low-lying coastal systems, due to threat of sea level rise and increased risk from extreme weather events;
- human health in populations with low adaptive capacity.

Regions:

- the Arctic, because of the impacts of high rates of projected warming on natural systems and human communities;
- Africa, because of low adaptive capacity and projected climate change impacts;
- small islands, where there is high exposure of population and infrastructure to projected climate change impacts;
- Asian and African megadeltas, due to large populations and high exposure to sea level rise, storm surges and river flooding.

Ocean Acidification. The uptake of anthropogenic carbon since 1750 has led to the ocean becoming more acidic with an average decrease in pH of 0.1 units. Projections based on SRES scenarios give a reduction in average global surface ocean pH of between 0.14 and 0.35 units over the 21st century. While the effects of observed ocean acidification on the marine biosphere are as yet undocumented, the progressive acidification of oceans is expected to have negative impacts on marine shell-forming organisms (e.g. corals) and their dependent species.

Altered frequencies and intensities of extreme weather, together with sea level rise, are expected to have mostly adverse effects on natural and human systems.

{Examples of extreme events from Table SPM.3 include fewer cold and more hot days and nights, more heat waves, more heavy precipitation events, larger land area in drought, more strong hurricanes, and increased incidence of extreme high sea level. Each of these changes is associated with a variety of impacts on agriculture, forestry and ecosystems; water resources; human health; and industry, settlements, and society.}

Anthropogenic warming and sea level rise would continue for centuries due to the timescales associated with climate processes and feedbacks, even if greenhouse gases concentrations were to be stabilized.

Anthropogenic warming could lead to some impacts that are abrupt or irreversible, depending upon the rate and magnitude of the climate change.

- Partial loss of ice sheets on polar land could imply meters of sea level rise, major changes in coastlines and inundation of low-lying areas, with greatest effects in river deltas and low-lying

islands. Such changes are projected to occur over millennial time scales, but more rapid sea level rise on century time scales cannot be excluded.

- Climate change is *likely* to lead to some irreversible impacts. There is *medium confidence* that approximately 20-30% of species assessed so far are likely to be at increased risk of extinction if increases in global average warming exceed 1.5-2.5°C (relative to 1980-1999). As global average temperature increase exceeds about 3.5°C, model projections suggest significant extinctions (40-70% of species assessed) around the globe.
- Based on current model simulations, the meridional overturning circulation (MOC) of the Atlantic Ocean will *very likely* slow down during the 21st century; nevertheless temperatures over the Atlantic and Europe are projected to increase. The MOC is *very unlikely* to undergo a large abrupt transition during the 21st century. Longer-term MOC changes cannot be assessed with confidence. Impacts of large-scale and persistent changes in the MOC are *likely* to include changes in marine ecosystem productivity, fisheries, ocean CO₂ uptake, oceanic oxygen concentrations and terrestrial vegetation.

4. Adaptation and mitigation options

A wide array of adaptation options is available, but more extensive adaptation than is currently occurring is required to reduce vulnerability to climate change. There are barriers, limits and costs, which are not fully understood.

Adaptive capacity is intimately connected to social and economic development but is unevenly distributed across and within societies.

[T]here is high agreement and much evidence of substantial economic potential for the mitigation of global greenhouse gas emissions over the coming decades that could offset the projected growth of global emissions or reduce emissions below current levels.

- No single technology can provide all of the mitigation potential in any sector. The economic mitigation potential... can only be achieved when adequate policies are in place and barriers removed.
- [M]itigation opportunities with net negative costs [i.e. net savings] have the potential to reduce emissions by around 6 GtCO₂-eq/yr in 2030, realizing which requires dealing with implementation barriers.

Future energy infrastructure investment decisions, expected to exceed 20 trillion US\$ between 2005 and 2030, will have long-term impacts on greenhouse gas emissions, because of the long life-times of energy plants and other infrastructure capital stock. The widespread diffusion of low-carbon technologies may take many decades, even if early investments in these technologies are made attractive. Initial estimates show that returning global energy-related CO₂ emissions to 2005 levels by 2030 would require a large shift in investment patterns, although the net additional investment required ranges from negligible to 5-10%.

A wide variety of policies and instruments are available to governments to create the incentives for mitigation action. Their applicability depends on national circumstances and sectoral context.

- They include integrating climate policies in wider development policies, regulations and standards, taxes and charges, tradable permits, financial incentives, voluntary agreements, information instruments, and research, development and demonstration (RD&D).
- An effective carbon-price signal could realize significant mitigation potential in all sectors. Modeling studies show global carbon prices rising to 20-80 US\$/tCO₂-eq by 2030 are consistent with stabilization at around 550 ppm CO₂-eq by 2100. For the same stabilization level, induced technological change may lower these price ranges to 5-65 US\$/tCO₂-eq in 2030.
- There is *high agreement* and *much evidence* that mitigation actions can result in near-term co-benefits (e.g., improved health due to reduced air pollution) that may offset a substantial fraction of mitigation costs.
- There is *high agreement* and *medium evidence* that Annex I countries' actions may affect the global economy and global emissions, although the scale of carbon leakage remains uncertain.
- Fossil fuel exporting nations (in both Annex I and non-Annex I countries) may expect, as indicated in the [2001 IPCC assessment report], lower demand and prices and lower GDP growth due to mitigation policies. The extent of this spill over depends strongly on assumptions related to policy decisions and oil market conditions.
- There is also *high agreement* and *medium evidence* that changes in lifestyle, behavior patterns and management practices can contribute to climate change mitigation across all sectors.

Many options for reducing global greenhouse gas emissions through international cooperation exist. There is *high agreement* and *much evidence* that notable achievements of the UNFCCC and its Kyoto Protocol are the establishment of a global response to climate change, stimulation of an array of national policies, and the creation of an international carbon market and new institutional mechanisms that may provide the foundation for future mitigation efforts. Progress has also been made in addressing adaptation within the UNFCCC...

- Greater cooperative efforts and expansion of market mechanisms will help to reduce global costs for achieving a given level of mitigation, or will improve environmental effectiveness. Efforts can include diverse elements such as emissions targets; sectoral, local, sub-national and regional actions; RD&D programs; adopting common policies; implementing development oriented actions; or expanding financing instruments.
- In several sectors, climate response options can be implemented to realize synergies and avoid conflicts with other dimensions of sustainable development. Decisions about macroeconomic and other non-climate policies can significantly affect emissions, adaptive capacity and vulnerability.
- Making development more sustainable can enhance mitigative and adaptive capacities, reduce emissions, and reduce vulnerability, but there may be barriers to implementation. On the other hand, it is *very likely* that climate change can slow the pace of progress towards sustainable development. Over the next half-century, climate change could impede achievement of the Millennium Development Goals.

5. The long-term perspective

Determining what constitutes “dangerous anthropogenic interference with the climate system” in relation to Article 2 of the UNFCCC involves value judgments. Science can support informed decisions on this issue, including by providing criteria for judging [key vulnerabilities].

The five “reasons for concern” identified in the [2001 IPCC assessment report] remain a viable framework to consider key vulnerabilities. These “reasons” are assessed here to be stronger than in the [2001 IPCC assessment report]. Many risks are identified with higher confidence. Some risks are projected to be larger or to occur at lower increases in temperature.

1. *Risks to unique and threatened systems.* There is **new and stronger evidence** of observed impacts of climate change on unique and vulnerable systems (such as polar and high mountain communities and ecosystems), with increasing levels of adverse impacts as temperatures increase further. ... There is **medium confidence** that approximately 20-30% of plant and animal species assessed so far are likely to be at increased risk of extinction if increases in global average temperature exceed 1.5-2.5°C over [1990] levels. Confidence has increased that a 1-2°C increase in global mean temperature above 1990 levels (about 1.5-2.5°C above pre-industrial) poses significant risks to many unique and threatened systems including many biodiversity hotspots. Corals are vulnerable to thermal stress and have low adaptive capacity. ... Increasing vulnerability of indigenous communities in the Arctic and small island communities to warming is projected.
2. *Risks of extreme weather events.* Responses to some recent extreme events reveal higher levels of vulnerability than the [2001 IPCC assessment report]. There is now higher confidence in the projected increases in droughts, heatwaves, and floods as well as their adverse impacts.
3. *Distribution of impacts and vulnerabilities.* There is increasing evidence of greater vulnerability of specific groups such as the poor and elderly in not only developing but also developed countries. Moreover, there is increased evidence that low-latitude and less-developed areas generally face greater risk, for example in dry areas and mega-deltas.
4. *Aggregate impacts.* Compared to the [2001 IPCC assessment report], initial net market-based benefits from climate change are projected to peak at a lower magnitude of warming, while damages would be higher for larger magnitudes of warming. The net costs of impacts of increased warming are projected to increase over time.
5. *Risks of large-scale singularities.* There is **high confidence** that global warming over many centuries would lead to a sea level rise contribution from thermal expansion alone which is projected to be much larger than observed over the 20th century, with loss of coastal area and associated impacts. There is better understanding than in the [2001 IPCC assessment report] that the risk of additional contributions to sea level rise from both the Greenland and possibly Antarctic ice sheets may be larger than projected by ice sheet models and could occur on century time scales.

There is **high confidence** that neither adaptation nor mitigation alone can avoid all climate change impacts; however, they can complement each other and together can significantly reduce the risks of climate change.

- Adaptation is necessary in the short and longer term to address impacts resulting from the warming that would occur even for the lowest stabilization scenarios assessed.
- Unmitigated climate change would, in the long term, be **likely** to exceed the capacity of natural, managed and human systems to adapt. The time at which such limits could be reached will vary between sectors and regions.
- Early mitigation actions would avoid further locking in carbon intensive infrastructure and reduce climate change and associated adaptation needs.

Many impacts can be reduced, delayed or avoided by mitigation. Mitigation efforts and investments over the next two to three decades will have a large impact on opportunities to achieve lower stabilization levels. Delayed emission reductions significantly constrain the opportunities to achieve lower stabilization levels and increase the risk of more severe climate change impacts.

In order to stabilize the concentration of greenhouse gases in the atmosphere, emissions would need to peak and decline thereafter. The lower the stabilization level, the more quickly this peak and decline would need to occur. {Note: to stabilize below 490 ppm, emissions must peak by 2015.}

Table SPM.6. Characteristics of post-[2001 IPCC assessment report] stabilization scenarios and resulting long-term equilibrium global average temperature and the sea level rise component from thermal expansion only [contributions from ice sheets could be much larger].

Category	CO ₂ concentration at stabilization (2005 = 379 ppm) ^(b)	CO ₂ -equivalent Concentration at stabilization including GHGs and aerosols (2005 = 375 ppm) ^(b)	Peaking year for CO ₂ emissions ^(a, c)	Change in global CO ₂ emissions in 2050 (% of 2000 emissions) ^(a, c)	Global average temperature increase above pre-industrial at equilibrium, using "best estimate" climate sensitivity ^{(d), (e)}	Global average sea level rise above pre-industrial at equilibrium from thermal expansion only ^(f)	Number of assessed scenarios
	ppm	ppm	Year	Percent	°C	metres	
I	350 – 400	445 – 490	2000 – 2015	-85 to -50	2.0 – 2.4	0.4 – 1.4	6
II	400 – 440	490 – 535	2000 – 2020	-60 to -30	2.4 – 2.8	0.5 – 1.7	18
III	440 – 485	535 – 590	2010 – 2030	-30 to +5	2.8 – 3.2	0.6 – 1.9	21
IV	485 – 570	590 – 710	2020 – 2060	+10 to +60	3.2 – 4.0	0.6 – 2.4	118
V	570 – 660	710 – 855	2050 – 2080	+25 to +85	4.0 – 4.9	0.8 – 2.9	9
VI	660 – 790	855 – 1130	2060 – 2090	+90 to +140	4.9 – 6.1	1.0 – 3.7	5

There is **high agreement** and **much evidence** that all stabilization levels assessed can be achieved by deployment of a portfolio of technologies that are either currently available or expected to be commercialized in coming decades, assuming appropriate and effective incentives are in place for their development, acquisition, deployment and diffusion, and addressing related barriers.

- All assessed stabilization scenarios indicate that 60-80% of the reductions would come from energy supply and use, and industrial processes, with energy efficiency playing a key role in many scenarios. Including non-CO₂ and CO₂ land-use and forestry mitigation options provides greater flexibility and cost-effectiveness. Low stabilization levels require early investments and substantially more rapid diffusion and commercialization of advanced low-emissions technologies.
- Without substantial investment flows and effective technology transfer, it may be difficult to achieve emission reduction at a significant scale. Mobilizing financing of incremental costs of low-carbon technologies is important.

The macro-economic costs of mitigation generally rise with the stringency of the stabilization target. For specific countries and sectors, costs vary considerably from the global average.

- In 2050, global average macro-economic costs for mitigation towards stabilization between 710 and 445ppm CO₂-eq are between a 1% gain and 5.5% decrease of global GDP.
- This corresponds to slowing average annual global GDP growth by less than 0.12 percentage points.