Global warming has become perhaps the most complicated issue facing world leaders. Warnings from the scientific community are becoming louder, as an increasing body of science points to rising dangers from the ongoing buildup of human-related greenhouse gases — produced mainly by the burning of fossil fuels and forests.

Global emissions of carbon dioxide were at a record high in 2011 and were likely to take a similar jump in 2012, scientists reported in early December 2012 — the latest indication that efforts to limit such emissions are failing.

Over all, global emissions jumped 3 percent in 2011 and are expected to jump another 2.6 percent in 2012, researchers reported.

The new figures show that emissions are falling, slowly, in some of the most advanced countries, including the United States. That apparently reflects a combination of economic weakness, the transfer of some manufacturing to developing countries and conscious efforts to limit emissions, like the renewable power targets that many American states have set. The boom in the natural gas supply from hydraulic fracturing is also a factor, since natural gas is supplanting coal at many power stations, leading to lower emissions.

But the decline of emissions in the developed countries is more than matched by continued growth in developing countries like China and India, the new figures show. Coal, the dirtiest and most carbon-intensive fossil fuel, is growing fastest, with coal-related emissions leaping more than 5 percent in 2011, compared with the previous year.

Emissions continue to grow so rapidly that an international goal of limiting the ultimate warming of the planet to 3.6 degrees, established three years ago, is on the verge of becoming unattainable, said researchers affiliated with the Global Carbon Project, a network of scientists that tracks emissions.

Yet nations around the world, despite a formal treaty pledging to limit warming — and 20 years of negotiations aimed at putting it into effect — have shown little appetite for the kinds of controls required to accomplish that goal.

For almost two decades, the United Nations has sponsored annual global talks, the United Nations Framework Convention on Climate Change, an international treaty signed nearly 200 countries to cooperatively discuss global climate change and its impact. The conferences operate
on the principle of consensus, meaning that any of the participating nations can hold up an agreement.

The conflicts and controversies discussed are monotonously familiar: the differing obligations of industrialized and developing nations, the question of who will pay to help poor nations adapt, the urgency of protecting tropical forests and the need to rapidly develop and deploy clean energy technology.

2012 Was Hottest Year Ever in U.S.

In January 2013, the National Climatic Data Center in Asheville, N.C., announced that 2012 was the hottest year ever in the contiguous United States since records began in 1895. The year 2012 brought a blistering March heat wave, a severe drought in the Corn Belt and a massive storm that caused broad devastation in mid-Atlantic states.

The temperature differences between years are usually measured in fractions of a degree, but 2012 blew away the previous record, set in 1998, by a full degree Fahrenheit.

If that does not sound so impressive, consider that 34,008 new daily high records were set at weather stations across the country, compared with only 6,664 new record lows, according to a count maintained by the Weather Channel meteorologist Guy Walton, using federal temperature records.

That ratio, which was roughly in balance as recently as the 1970s, has been out of whack for decades as the country has warmed, but never by as much as it was in 2012.

Scientists said that natural variability almost certainly played a role in last year’s extreme heat and drought. But many of them expressed doubt that such a striking new record would have been set without the backdrop of global warming caused by the human release of greenhouse gases.

Background

Scientists learned long ago that the earth’s climate has powerfully shaped the history of the human species — biologically, culturally and geographically. But only in the last few decades has research revealed that humans can be a powerful influence on the climate, as well.

A growing body of scientific evidence indicates that since 1950, the world’s climate has been warming, primarily as a result of emissions from unfettered burning of fossil fuels and the razing of tropical forests. Such activity adds to the atmosphere’s invisible blanket of carbon dioxide and other heat-trapping “greenhouse” gases. Recent research has shown that methane, which flows from landfills, livestock and oil and gas facilities, is a close second to carbon dioxide as an impact on the atmosphere.

That conclusion has emerged through a broad body of analysis in fields as disparate as glaciology, the study of glacial formations, and palynology, the study of the distribution of
pollen grains in lake mud. It is based on a host of assessments by the world’s leading organizations of climate and earth scientists.

In the last several years, the scientific case that the rising human influence on climate could become disruptive has become particularly robust.

Some fluctuations in the earth’s temperature are inevitable regardless of human activity — because of decades-long ocean cycles, for example. But centuries of rising temperatures and seas lie ahead if the release of emissions from the burning of fossil fuels and deforestation continues unabated, according to the Intergovernmental Panel on Climate Change, a group that shared the 2007 Nobel Peace Prize with former Vice President Al Gore.

In addition, a report released by the I.P.C.C. in November 2011 predicted that global warming will cause more dangerous and “unprecedented extreme weather” in the future.

Despite the scientific consensus on these basic conclusions, enormously important details remain murky. That reality has been seized upon by some groups and scientists disputing the overall consensus and opposing changes in energy policies.

For example, estimates of the amount of warming that would result from a doubling of greenhouse gas concentrations (compared to the level just before the Industrial Revolution got under way in the early 19th century) range from 3.6 degrees to 8 degrees Fahrenheit. The intergovernmental climate panel said it could not rule out even higher temperatures. While the low end could probably be tolerated, the high end would almost certainly result in calamitous, long-lasting disruptions of ecosystems and economies, a host of studies have concluded. A wide range of economists and earth scientists say that level of risk justifies an aggressive response.

Other questions have persisted despite a century-long accumulation of studies pointing to human-driven warming. The rate and extent at which sea levels will rise in this century as ice sheets erode remains highly uncertain, even as the long-term forecast of centuries of retreating shorelines remains intact. Scientists are struggling more than ever to disentangle how the heat building in the seas and atmosphere will affect the strength and number of tropical cyclones. The latest science suggests there will be more hurricanes and typhoons that reach the most dangerous categories of intensity, but fewer storms overall.

Steps Toward a Response

The debate over climate questions pales next to the fight over what to do, or not do, in a world where fossil fuels still underpin both rich and emerging economies.

With the completion of the United Nations Framework Convention on Climate Change at the Earth Summit in 1992, the world’s nations pledged to avoid dangerously disrupting the climate through the buildup of greenhouse gases, but they never defined how much warming was too much.
Nonetheless, recognizing that the original climate treaty was proving ineffective, all of the world’s industrialized countries except for the United States accepted binding restrictions on their greenhouse gas emissions under the Kyoto Protocol, which was negotiated in Japan in 1997. That accord took effect in 2005 and its gas restrictions expire in 2012. The United States signed the treaty, but it was never submitted for ratification in the face of overwhelming opposition in the Senate because the pact required no steps by China or other fast-growing developing countries.

It took until 2009 for the leaders of the world’s largest economic powers to agree on a dangerous climate threshold: an increase of 2 degrees Celsius (3.6 degrees Fahrenheit) from the average global temperature recorded just before the Industrial Revolution kicked into gear. (This translates into an increase of 1.3 degrees Fahrenheit above the Earth’s current average temperature, about 59 degrees.)

The Group of 8 industrial powers also agreed in 2009 to a goal of reducing global emissions 50 percent by 2050, with the richest countries leading the way by cutting their emissions 80 percent. But they did not set a baseline from which to measure that reduction, and so far firm interim targets — which many climate scientists say would be more meaningful — have not been defined.

At the same time, fast-growing emerging economic powerhouses, led by China and India, opposed taking on mandatory obligations to curb their emissions. They said they will do what they can to rein in growth in emissions — as long as their economies do not suffer.

In many ways, the debate over global climate policy is a result of a global “climate divide.” Emissions of carbon dioxide per person range from less than 2 tons per year in India, where 400 million people lack access to electricity, to more than 20 in the United States. The richest countries are also best able to use wealth and technology to insulate themselves from climate hazards, while the poorest, which have done the least to cause the problem, are the most exposed.

2010 U.N. Conference: Cancún

The 2010 United Nations Framework Convention on Climate Change in Cancún, Mexico, produced only modest achievements but ended with the toughest issues unresolved. The package that was approved, known as the Cancún Agreements, set up a new fund to help poor countries adapt to climate changes, created new mechanisms for transfer of clean energy technology, provided compensation for the preservation of tropical forests and strengthened the emissions reductions pledges that came out of the U.N. climate change meeting in Copenhagen in 2009.

The conference approved the agreement over the objections of Bolivia, which condemned the pact as too weak. But those protests did not block its acceptance. Delegates from island states and the least-developed countries warmly welcomed the pact because it would start the flow of billions of dollars to assist them in adopting cleaner energy systems and adapting to inevitable changes in the climate, like sea rise and drought.
But where the promised aid from wealthy nations — $100 billion — would come from was left unresolved.

2011 U.N. Conference: Durban

At the 2011 conference delegates from about 200 nations gathered together in Durban, South Africa. One of the issues left unresolved was the future of the Kyoto Protocol, the 1997 agreement that requires major industrialized nations to meet targets on emissions reduction but imposes no mandates on developing countries, including emerging economic powers and sources of global greenhouse gas emissions like China, India, Brazil and South Africa.

The United States is not a party to the protocol, having refused to even consider ratifying it because of those asymmetrical obligations. Some major countries, including Canada, Japan and Russia, have said they will not agree to an extension of the protocol next year unless the unbalanced requirements of developing and developed countries are changed. That is similar to the United States’ position, which is that any successor treaty must apply equally to all major economies.

Expectations for the meeting were low, and it ended with modest accomplishments: the promise to work toward a new global treaty in coming years and the establishment of a new climate fund.

The deal on a future treaty renewed the Kyoto Protocol for several more years. But it also began a process for replacing the protocol with something that treats all countries — including the economic powerhouses China, India and Brazil — equally. The future treaty deal was the most highly contested element of a package of agreements that emerged from the extended talks among the nations here.

The expiration date of the protocol — 2017 or 2020 — and the terms of any agreement that replaces it will be negotiated at future sessions.

The delegates also agreed on the creation of a fund to help poor countries adapt to climate change — though the precise sources of the money have yet to be determined — and to measures involving the preservation of tropical forests and the development of clean-energy technology. The reserve, called the Green Climate Fund, would help mobilize a promised $100 billion a year in public and private financing by 2020 to assist developing countries in adapting to climate change and converting to clean energy sources.

2012 U.N. Conference: Doha

In December 2012, delegates from 190 countries around the world met in Doha, Qatar, for the annual United Nations forum on climate change. The agenda was modest, after disappointing sessions in previous years, and so was the outcome. The delegates agreed to extend the increasingly ineffective Kyoto Protocol a few years and to commit to more ambitious — but unspecified — actions to reduce emissions of climate-altering gases.
Wealthy nations put off for a year resolution of the dispute over providing billions of dollars in aid to countries most heavily affected by climate change. Industrial nations have pledged to secure $100 billion a year by 2020 in public and private financing to help poor countries cope with climate change, but have been vague about what they plan to do before then.

Only a handful of countries, not including the United States, have made concrete financial pledges for adaptation aid over the next few years.

The participants noted with “grave concern” the widening gap between what countries have promised to do to reduce emissions and the growing concentration of greenhouse gases in the atmosphere. They declared it unlikely that on the current path the world would be able to keep global temperatures from rising more than two degrees Celsius (3.6 degrees Fahrenheit) from pre-industrial times, a central goal of the United Nations process.

But the group left for future years any plan for addressing the mismatch between goals and reality, merely stating an intention to “identify and explore in 2013 options for a range of actions to close the pre-2020 ambition gap.” The plan to be adopted by 2020 would be fundamentally different from Kyoto, as it would require action by all nations, not just rich countries — leaving behind a longstanding division of nations into industrialized perpetrators and developing-world victims.

The U.S. and Climate Change

The United States has been criticized at the United Nations gatherings for years, in part because of its rejection of the Kyoto framework and in part because it has not adopted a comprehensive domestic program for reducing its own greenhouse gas emissions. President Obama has pledged to reduce American emissions 17 percent below 2005 levels by 2020, but his preferred approach, a nationwide cap-and-trade system for carbon pollution, was passed by the House in 2009 but died in the Senate the next year. United States emissions are down about 6 percent over the past five years, largely because of the drop in industrial and electricity production caused by the recession.

In January 2011, the Environmental Protection Agency began imposing regulations related to greenhouse gas emissions. The immediate effect on utilities, refiners and major manufacturers was minor, with the new rules applying only to those planning to build large new facilities or make major modifications to existing plants. Over the next decade, however, the agency plans to regulate virtually all sources of greenhouse gases, imposing efficiency and emissions requirements on nearly every industry and every region.

In March 2012, the E.P.A. unveiled a draft rule that would limit carbon dioxide emissions from new power plants to 1,000 pounds per megawatt-hour.

Recently built power plants fired by natural gas already easily met the new standards, so the rule presented little obstacle for new gas plants. But coal-fired plants faced a far greater challenge, since no easily accessible technology can bring their emissions under the limit. Coal-fired plants
are a major source emissions associated with global warming. The new rules do not apply to existing plants.

The declining price of natural gas has made it the fuel of choice in recent years for companies planning new plants. The E.P.A.’s move follows a shift that is already unfolding in the electric power market.

The proposed rule is rooted in a 2007 directive from the Supreme Court instructing the E.P.A. to decide whether carbon dioxide was a pollutant under the Clean Air Act. In late 2009, the agency declared that it was, and so had to be regulated.

Environmental groups generally applauded the standards, although some expressed disappointment with the agency’s decision not to regulate existing power plants for the moment.

A Non-Issue in U.S. Presidential Campaign

During the 2012 presidential campaign, neither President Obama nor Mitt Romney, his Republican challenger, spoke much about climate change, despite the fact that both men agree that the world is warming and that humans are at least partly to blame. None of the moderators of the four general-election debates asked about climate change, nor did any of the candidates broach the topic.

Throughout the campaign, Mr. Obama and Mr. Romney seemed most intent on trying to outdo each other as lovers of coal, oil and natural gas — the very fuels most responsible for rising levels of carbon dioxide in the atmosphere.

Mr. Obama has supported broad climate change legislation, financed extensive clean energy projects and pushed new regulations to reduce global warming emissions from cars and power plants. But neither he nor Mr. Romney laid out during the campaign a legislative or regulatory program to address the fundamental questions arising from one of the most vexing economic, environmental, political and humanitarian issues to face the planet.

The E.U. Gets Tough With Airline Emissions

In December 2011, the European Union’s highest court endorsed the bloc’s plan to begin charging the world’s biggest airlines for their greenhouse gas emissions from Jan. 1, 2012, setting the stage for a potentially costly trade war with the United States, China and other countries.

A group of United States airlines had argued that forcing them to participate in the potentially costly emissions-trading system infringed on national sovereignty and conflicted with existing international aviation treaties.

But in a final ruling, the European Court of Justice in Luxembourg affirmed an opinion issued in October by its advocate general, who had rejected their claim.
The court’s decision came amid increasing pressure from some of the biggest trading partners of the 27-member bloc to suspend or amend application of the legislation to expressly exclude non-E.U. countries — at least initially. Failing that, several governments have vowed to take their own legal action or retaliate with countervailing trade measures.

Although airlines initially will receive most of the permits they will need for free, the European Union estimates that ticket prices could rise by as much as €12, or nearly $16, on some long-haul flights to cover the cost of additional permits required.

Airlines for America, an industry lobby group and one of the plaintiffs in the case, said that its members would be required to pay more than $3.1 billion to the E.U. between 2012 and 2020. It said its members would comply with the system “under protest,” but would also review options for pursuing the case in Britain’s High Court, which had referred the original complaint to the European court in 2009.

The European initiative involves folding aviation into the Union’s six-year-old Emissions Trading System, in which polluters can buy and sell a limited quantity of permits, each representing a ton of carbon dioxide. The legislation mandates that airlines account for their emissions for the entirety of any flight that takes off from — or lands at — any airport in the 27-member bloc.

The goal, European officials have said, is to speed up the adoption of greener technologies at a time when air traffic, which represents about 3 percent of global carbon dioxide emissions, is growing much faster than gains in efficiency.

A Global Initiative Led by the U.S.

In February 2012, Secretary of State Hillary Rodham Clinton announced a joint international effort focused on reducing emissions of common pollutants that contribute to rapid climate change and widespread health problems.

Impatient with the slow pace of international negotiations, the United States and a small group of countries — Bangladesh, Canada, Ghana, Mexico and Sweden as well as the United Nations Environment Program — started a program that will address short-lived pollutants like soot (also referred to as black carbon), methane and hydrofluorocarbons that have an outsize influence on global warming, accounting for 30 to 40 percent of global warming. Soot from diesel exhausts and the burning of wood, agricultural waste and dung for heating and cooking causes an estimated two million premature deaths a year, particularly in the poorest countries.

Scientists say that concerted action on these substances can reduce global temperatures by 0.5 degrees Celsius by 2050 and prevent millions of cases of lung and heart disease by 2030.

The United States intends to contribute $12 million and Canada $3 million over two years to get the program off the ground and to help recruit other countries to participate. The United Nations Environment Program will run the project.
Officials hope that by tackling these fast-acting, climate-changing agents they can get results quicker than through the laborious and highly political negotiations conducted under the United Nations Framework Convention on Climate Change.

**Court Backs E.P.A. on Emissions Limits**

In late June 2012, a federal appeals court in Washington upheld a finding by the Environmental Protection Agency that heat-trapping gases from industry and vehicles endanger public health, dealing a decisive blow to companies and states that had sued to block agency rules.

A three-judge panel declared that the agency was “unambiguously correct” that the Clean Air Act requires the federal government to impose limits once it has determined that emissions are causing harm.

The judges unanimously dismissed arguments from industry that the science of global warming was not well supported and that the E.P.A. had based its judgment on unreliable studies. “This is how science works,” they wrote. “The E.P.A. is not required to reprove the existence of the atom every time it approaches a scientific question.”

In addition to upholding the E.P.A.’s so-called endangerment finding, the court let stand related rules setting limits on greenhouse gas emissions from cars and limiting emissions from stationary sources. Opponents had also challenged the agency’s timetable for enforcement and its rules singling out big polluters, but the court said the plaintiffs lacked the standing to do so.

Fourteen states, led by Virginia and Texas, had sued to block the agency rules. Fifteen states, including New York, California and Massachusetts, went to court to support the agency. Massachusetts and California were among the states that won a landmark Supreme Court decision in 2007, Massachusetts v. Environmental Protection Agency, that led to the agency’s endangerment finding. The attorney general of Virginia said he would appeal the court’s ruling.

**Study Links Climate Change and Ozone Loss**

According to a study published in July 2012, strong summer thunderstorms that pump water high into the upper atmosphere pose a threat to the protective ozone layer over the United States, drawing one of the first links between climate change and ozone loss over populated areas.

In the study, from the journal Science, Harvard University scientists reported that some storms send water vapor miles into the stratosphere — which is normally drier than a desert — and showed how such events could rapidly set off ozone-destroying reactions with chemicals that remain in the atmosphere from CFCs, the now-banned refrigerant gases.

The risk of ozone damage, scientists said, could increase if global warming leads to more such storms.

“It’s the union between ozone loss and climate change that is really at the heart of this,” said James G. Anderson, an atmospheric scientist and the lead author of the study.
For years, Dr. Anderson said, he and other atmospheric scientists were careful to keep the two concepts separate. “Now, they’re intimately connected,” he said.

Ozone helps shield people, animals and crops from damaging ultraviolet rays from the sun. Much of the concern about the ozone layer has focused on Antarctica, where a seasonal hole, or thinning, has been seen for two decades, and the Arctic, where a hole was observed last year. But those regions have almost no population.

A thinning of the ozone layer over the United States during summers could mean an increase in ultraviolet exposure for millions of people and a rise in the incidence of skin cancer, the researchers said.

The findings were based on sound science, Dr. Anderson and other experts said, but much more research is needed, including direct measurements in the stratosphere in areas where water vapor was present after storms.

**Carbon Credits Gone Awry Raise Output of Harmful Gas**

When the United Nations wanted to help slow climate change, it established what seemed a sensible system. Greenhouse gases were rated based on their power to warm the atmosphere. The more dangerous the gas, the more that manufacturers in developing nations would be compensated as they reduced their emissions.

But where the United Nations envisioned environmental reform, some manufacturers of gases used in air-conditioning and refrigeration saw a lucrative business opportunity. They quickly figured out that they could earn one carbon credit by eliminating one ton of carbon dioxide, but could earn more than 11,000 credits by simply destroying a ton of an obscure waste gas normally released in the manufacturing of a widely used coolant gas.

That is because that byproduct has a huge global warming effect. The credits could be sold on international markets, earning tens of millions of dollars a year. That incentive has driven plants in the developing world not only to increase production of the coolant gas but also to keep it high — a huge problem because the coolant itself contributes to global warming and depletes the ozone layer. That coolant gas is being phased out under a global treaty, but the effort has been a struggle.

So since 2005 the 19 plants receiving the waste gas payments have profited handsomely from an unlikely business: churning out more harmful coolant gas so they can be paid to destroy its waste byproduct. The high output keeps the prices of the coolant gas irresistibly low, discouraging air-conditioning companies from switching to less-damaging alternative gases. That means, critics say, that United Nations subsidies intended to improve the environment are instead creating their own damage.

The United Nations and the European Union, through new rules and an outright ban, are trying to undo this unintended bonanza. But the lucrative incentive has become so entrenched that efforts to roll it back are proving tricky, even risky.
China and India, where most of the 19 factories are, have been resisting mightily. The manufacturers have grown accustomed to an income stream that in some years accounted for half their profits. The windfall has enhanced their power and influence. As a result, many environmental experts fear that if manufacturers are not paid to destroy the waste gas, they will simply resume releasing it into the atmosphere.

**Arctic Sea Ice Sets a New Low**

The drastic melting of Arctic sea ice has finally ended for 2012, scientists announced on Sept. 19, but not before demolishing the previous record — and setting off new warnings about the rapid pace of change in the region.

The apparent low point for the year was reached on Sept. 16, according to the National Snow and Ice Data Center, which said that sea ice that day covered about 1.32 million square miles, or 24 percent, of the surface of the Arctic Ocean. The previous low, set in 2007, was 29 percent.

When satellite tracking began in the late 1970s, sea ice at its lowest point in the summer typically covered about half the Arctic Ocean, but it has been declining in fits and starts over the decades.

Scientists consider the rapid warming of the region to be a consequence of the human release of greenhouse gases, and they see the melting as an early warning of big changes to come in the rest of the world.

Some of them also think the collapse of Arctic sea ice has already started to alter atmospheric patterns in the Northern Hemisphere, contributing to greater extremes of weather in the United States and other countries, but that case is not considered proven.

The sea ice is declining much faster than had been predicted in the last big United Nations report on the state of the climate, published in 2007. The most sophisticated computer analyses for that report suggested that the ice would not disappear before the middle of this century, if then.

Now, some scientists think the Arctic Ocean could be largely free of summer ice as soon as 2020. But governments have not responded to the change with any greater urgency about limiting greenhouse emissions. To the contrary, their main response has been to plan for exploitation of newly accessible minerals in the Arctic, including drilling for more oil.

A prime concern is the potential for a large rise in the level of the world’s oceans. The decline of Arctic sea ice does not contribute directly to that problem, since the ice is already floating and therefore displacing its weight in water.

But the disappearance of summer ice cover replaces a white, reflective surface with a much darker ocean surface, allowing the region to trap more of the sun’s heat, which in turn melts more ice. The extra heat in the ocean appears to be contributing to an accelerating melt of the nearby Greenland ice sheet, which does contribute to the rise in sea level.
Related: More About Global Warming From The Learning Network

Graphic: Record-Setting Heat Across the U.S. in 2012

Map of which parts of the country were warmest.