UCRL-JC-131556
PREPRINT

Gulf Coast Assessment Overview/Charge to the Workshop

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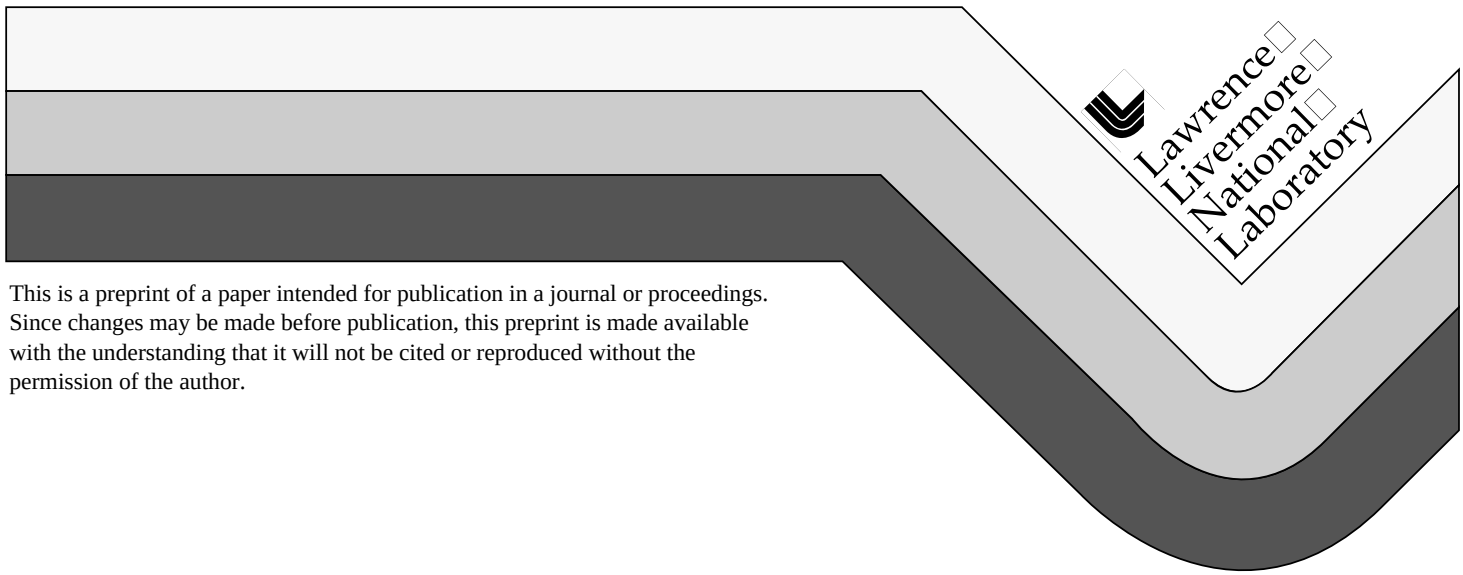
This paper was prepared for submittal to the
Gulf Coast Regional Workshop
Baton Rouge, LA
February 25-27, 1998

April 30, 1998



GULF COAST
ASSESSMENT OVERVIEW/CHARGE TO THE WORKSHOP

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Introduction

There are several reasons that the U. S. Global Change Research Program (USGCRP) has initiated the U.S. National Assessment: The Potential Consequences of Climate Variability and Change. The reasons all revolve around answering questions posed in Washington by members of Congress on behalf of their constituents--basically, the questions are:

> ***"So what? So what if the global average temperature warms a couple of degrees? What does that matter to citizens of my district? Of my State? Even of the United States? There are suggestions that we need to sharply reduce use of coal and oil and natural gas to protect the climate--what does this really mean? So what if the climate changes? Can't we just adapt to the changes? After all, people move all the time to warmer climates? So what will climate change really mean to all of us?"***

These are really good questions--and they deserve understandable answers. This workshop is part of the process for getting better answers to these "So What" questions.

The Science of Climate Change

These "So What" questions, however, were not the first questions that Congress asked. To understand how they got to these questions, it is useful to review the history of our understanding of the potential for climate change.

About 150 years ago, an English scientist started wondering what happened to all of the carbon generated by burning the coal they were using to drive the Industrial Revolution. Pretty clearly, it went up into the air with the smoke. The smoke particles all came down, coating everything with soot, but where did the rest of the carbon go. While scientists knew at the time that plants could capture CO_2, using the carbon to build their structure and releasing oxygen, that meant the carbon had to show up in trees--so the more they burned, the more trees there would need to be. But everyone was cutting down trees to make sailing ships and the charcoal was needed to make steel and sailing ships. Carbon dioxide could also be taken up by the oceans, but simple equilibrium chemistry indicated that all of the CO_2 would not get sucked up. After all, if that were the case, then why was there any CO_2 in the atmosphere at all. There had to be some fractionation, with some of the CO_2 going into the oceans, and some remaining in the atmosphere. As more and more coal was burned, the concentration in the air would clearly have to go up.

There were scattered measurements over the next century, with early hints in the late 1930s that the CO_2 concentration was indeed rising. Regular measurements of the concentration in really

[1] On assignment from the Lawrence Livermore National Laboratory with support from the US Department of Energy.

clean air started in 1957 on a mountaintop in Hawaii. Since that time we have also realized that the bubbles of air trapped in glacial ice can be analyzed to provide a record of the CO_2 concentration before regular monitoring began. From these analyses, a record of the CO_2 concentration has been constructed back now several hundred thousand years (Fig. 1).

By the end of the last century, it had also become clear that, like water vapor, the carbon dioxide in the air is an absorber and re-emitter of infrared radiation, creating a greenhouse effect that amplifies the warming influence of solar radiation. Much of the physics and thermodynamics of the greenhouse effect can be verified in the laboratory, from satellites, and from observations of other planets. There is no question that the greenhouse gases in the atmosphere--water vapor, CO_2, CH_4, etc.--are keeping the Earth significantly warmer than it would be in their absence. The real question is how much the climate will change in response to changes in atmospheric composition.

Based on geological evidence, American scientist T. C. Chamberlain suggested that climate changes in the past might have been caused, at least in part, by variations in the CO_2 concentration. Looking at evidence of past climate changes and their causes has been a major scientific activity ever since. There is now strong evidence this is the case, as seen in the results from the Vostok ice core (Figure 2). Russian scientists have extended the records back in time by using geological and biological evidence to reconstruct the climate and the CO_2 concentration for quite a number of past periods--from the time of the dinosaurs to the present. For all periods, they have found a close association. Quite clearly, nature views the relationship as quite close--providing some lessons we must recognize about what might happen as human activities change the CO_2 concentration.

Just before Chamberlain's suggestion, Swedish scientist Svante Arrhenius made the first estimate of how much the Earth would warm as a result of human activities. He calculated that there would be a warming of several degrees Celsius--roughly 4^o to 6^o C (about 7^o to 11^o F)--if the CO_2 concentration were doubled. At the time, Arrhenius thought this would take a very long time to occur for he was simply not able to envisage the rapid increase in emissions that would occur as a result of the spread of the automobile, aircraft, electricity, industry, and population.

Observations have generally borne out these predictions--with a few new twists. As shown in Figure 3, the global temperature record from 1860 to the present shows a warming of about 0.5 C. This warming is occurring quite rapidly in geological terms, and we are now at record warmth for modern civilization.

Adding CO_2 to the atmosphere is not all that human activities are doing to affect the Earth system. First, agriculture, industrial activities, and other societal activities are also increasing the concentrations of other greenhouse gases. Combustion of coal is leading to the addition of sulfate aerosols to the atmosphere; these small particles create the whitish haze covering and downwind of many industrial regions and they reflect some solar radiation back to space, which tends to cool the climate. Emissions of chlorofluorcarbons have also been contributing to stratospheric ozone depletion. These are not all of the effects, but we believe these are the largest effects at this time. At the same time, nature has not been simply quiet--there have been subtle changes in solar radiation, and there have been very large volcanic eruptions that introduce volcanic aerosols into the stratosphere. These aerosols, like sulfate aerosols, exert a cooling influence. While science has been able to gain some understanding of these effects, there remain uncertainties about precisely how much the changes will be, when they will occur, and what the potential is for surprises.

Identifying the Human Influence on Climate

In that human activities have been changing atmospheric composition for almost 200 years, we can consider the climate record in the context of how human activities are affecting the climate. Model simulations at present yield good agreement with observations if the mutual effects of the increasing concentrations of greenhouse gases and aerosols are considered along with the natural influence of small changes in solar radiation. Figure 4 shows the observed temperature record and a set model-simulated variations assuming different sensitivities of the climate to a doubling of the CO_2 concentration. The Intergovernmental Panel on Climate Change (IPCC) considers the value of 2.5^o C as its best estimate, which is slightly higher than the value of Arrhenius. However, uncertainties in understanding the climate have kept the IPCC from narrowing the preferred range of 1.5^o to 4.5^o C--about 2.5^o to 8^o F--for a doubling of the CO_2 concentration. While most models tend to give results near the central value, it is interesting that most of the evidence from studies of how past climates have varied give a result a bit above the central value. While scientists have not been able to narrow this range for nearly 20 years now, the evidence that the value is within this region keeps mounting.

Examining these results, combining them with studies of the patterns of temperature change, with evidence of rising soil and ocean temperatures, and with evidence of melting glaciers and rising sea level, soil temperatures, the IPCC concluded in 1995 that "the balance of evidence suggests that there is a discernible human influence on the global climate." Some would say, given the amount of evidence, that this is a very conservative conclusion. Others, citing a nearly 20-year satellite record of lower atmosphere temperatures, which some argue shows a slight cooling since 1979, suggest the IPCC conclusion was premature. However, after accounting for volcanic and El Nino influences, the scientists who have generated the satellite record see an underlying warming--and the longer balloon record of atmospheric temperatures to which they calibrate also shows a warming. Because of these results, and recognizing that the satellite record is less than 20 years long, the IPCC authors concluded that the satellite record is not incompatible with their conclusion that the human influence on climate is now becoming larger than the natural variations society has become accustomed to over the past several centuries.

Future Climate Change

If the rise in CO_2 concentration from 280 to about 370 ppmv has caused a warming of about 0.5^o C (1^o F), what will happen in the future? The IPCC has constructed a range of CO_2 and greenhouse gas emission scenarios for the next century--considering how population, technology, and development will occur. Because it is so hard to predict ahead, they have chosen a very wide range of possibilities--and this is an important cause of why estimates for the future are not--and cannot be--really precise.

Figure 5 shows the projections for the increase in the CO_2 concentration and in temperature, using global climate models and various emissions scenarios. The best estimate for the CO_2 concentration is that it will rise to about 700 ppmv, a level far above levels in recent history and not thought to have occurred on Earth in the last 40-50 million years at a time when the Earth was much warmer than at present.

Not only will temperatures increase, but because this warming will cause glaciers to melt and water to expand, sea level will rise. In addition, hurricanes may intensify (a recent model result for Pacific typhoons), storm tracks will change, rainfall and runoff patterns will change, and more. While we currently experience a great deal of variability from year-to-year--this El Nino

year being a very good example--what appears likely is that the range of variations will occur around new average conditions--creating new extremes, both wet and dry.

National and International Perspectives on Global Change

The first Presidential report on the potential for climate change and its consequences was issued in 1964. The nation had other things on its mind, and the Northern Hemisphere was actually cooling slightly, so there was not much political attention to the issue. During the late 1970s and then throughout the 1980s, there were more and more reports from scientific groups--both nationally from the National Academy of Sciences and from international groups. Politicians were starting to pay attention, and there were a number of hearings before Congress--especially in 1988 when there was a very severe drought in the central U.S. The questions that were being asked almost all focused on whether the climate would really change, whether the predictions could be believed, and how certain the science was.

For most members of Congress and the Administration, the questions have now changed, similarly for nations around the world. At the Rio summit on the Environment in 1992, the nations of the world enacted the Framework Convention on Climate Change. They committed themselves to a very important goal.

> *"stabilization of the greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner."*

With 160 nations now endorsing this goal, the nature of the discussion has changed. For all of the nations, the potential for very significant climate change during the next century has been demonstrated to a sufficient level that policymakers must now seek to understand the risks involved. Questions are now of two distinct types: Questions about what it would take to do something to prevent the climate from changing--that is to mitigate climate change, and questions about what climate change will mean if it does occur--that is to adapt and cope with climate change.

The Potential for Mitigation of Climate Change

Were CO_2 like any other pollutant, some sort of emissions control program would seem to be the cure. However, because coal, oil, and natural gas are mostly made up of carbon, instead of removing some trace amount of pollution, control would require capturing virtually all of the carbon--and that appears to be quite expensive. The only solution seems to be use less of the coal, oil, and natural gas that are adding CO_2 to the atmosphere.

The IPCC report summarizes a number of calculations of how much fossil fuel emissions must be cut to limit the continuing rise in CO_2 concentrations in the atmosphere. As shown in Figure 5, the cutbacks required are significant.

Last December, meeting in Kyoto, the developed nations agreed, subject to approval by their governments, that they would start the process of controlling emissions, reducing their emissions of greenhouse gases to several percent points below their 1990 levels by about 2010. Critics of the agreement abound. On the one hand, this agreement will not come close to meeting the stated goal of stopping the increase in concentrations of greenhouse gases as called

for in the Climate Convention. On the other hand, other critics of the agreement suggest that even this modest reduction in current emissions could be quite expensive. A third view is that technological improvements can make the cost of meeting this agreement quite low--or even beneficial--and so the proposed federal budget has new incentives for technology development.

Whatever view one takes, what is clear is that, over the coming decades, stabilizing the CO_2 concentration will require significantly more cutbacks in emissions--both by developed and developing nations--than are committed to in the Kyoto agreement. This does not mean that there is no purpose in starting to introduce controls--only that present agreements, hard as they may be to ratify and implement, are only a beginning on the path to stopping climate change. Unless we want to leave very different climate conditions for our grandchildren, emissions cutbacks must start very soon to slow the growth in emissions and then cut them back significantly.

The Need to Cope With Climate Change

If society cannot stop the build-up in greenhouse gases now, society will not be able to stop climate change. And even if society were to cut back global emissions significantly right now, the climate would still continue to change for some decades as a result of past emissions--it takes time for the climate to come to a new equilibrium. Even if emissions were to go to zero so that there were no further changes in the atmospheric concentrations of greenhouse gases, the warming over the next century would be as much as it has been over the past century (albeit only about 20% of what is projected to occur). With emissions continuing, climate change will increase. What is perhaps more worrisome is that sea level rise is projected to continue on for centuries as the oceans keep warming and glaciers keep melting.

What is very clear is that we will experience climate change. Recognizing this--and facing objections to cutting back emissions--those in Congress are increasingly asking questions about what climate change will mean: *So what if climate changes--how will climate change affect us? How will it affect the citizens in my district? The citizens of my state and region? And how will climate change affect the nation and the world? Are the effects of climate change really going to be important given all of the other changes that are occurring?*

At the global and national levels, some studies of the potential consequences of climate change have given indications of the types of changes that could occur. In that fossil fuels provide tremendous benefit to society, the global focus has been on major categories of changes to aspects of the environment that provide important services to humans. Thus, the types of impacts of most concern focus on potential consequences to human health, food production, water resources, communities in coastal regions, and the many and diverse aspects of potential impacts to forests, wetlands, grasslands, and many other types of ecosystems that provide both products and services to society.

The US National Assessment

Information on the general types of impacts is interesting, but it is not really very helpful in understanding what climate change will matter to each one of us or in understanding how we will need to adjust and try to cope with the changes. It is providing more specific answers that is the challenge of our national assessment.

The nation is so complex that no small group--whether of scientists or those in Washington--can just go off and write a simple explanation. Not only would such a select and distant group

likely not address the questions that really matter, but no one would believe what was written. The only way to get a good understanding of the climate and the human and societal dimensions of the problem is to initiate an extended dialog on the issues with those who will really feel the changes. These regional workshops are to be the beginning of this dialogue. The US Global Change Research Program is sponsoring a number of regional workshops around the country where the dialogue is getting started (see http://www.nacc.usgcrp.gov for further information).

We have learned several things from the nine workshops that have been held so far. First, we have learned that it helps to identify the key sectors in a region to provide a focus to the thinking about potentially large impacts. Second, it helps to start the discussion around four basic questions:

1. What environmental stresses are now affecting the critical sectors in the region and how might these stresses play out in the future?

2. How might climate amplify or moderate these stresses--or introduce new ones?

3. What further information is needed to more fully answer questions about climate impacts on these and other sectors?

4. What coping actions might help to alleviate the identified stresses, hopefully in a win-win way, so as to avoid the adverse impacts of climate change?

A story from the first workshop in the Central Great Plains might help to clarify how the process has worked at other workshops. Quite a number of ranchers came to that workshop--they were a bit reluctant to do so, in that they are often portrayed as part of the environmental problem--the cattle produce waste that pollutes river waters and methane that exert a strong warming influence on the climate; their plowing of the soils causes carbon in the soils to oxidize and become CO_2 that also induces warming and their animal and fertilizer wastes come down the Mississippi and may be causing the lifeless hypoxia zone in the Gulf of Mexico. How much worse can things get? Well, climate change is predicted to make it hotter in the summer, reducing soil moisture, and therefore reducing their crop yields. And cutting back fossil fuel emissions would lead to higher fuel prices. It all sounded pretty hopeless.

However, by the end of the workshop, things had turned around. Fossil fuel cutbacks will likely make a market for biomass fuels--so the animal waste becomes a resource that would earn the ranchers money instead of costing them money; similarly, the methane gas emissions can be a fuel resource. Shifting to no-till agriculture would require less fossil fuel, while also helping to enhance carbon build-up in the soils. Not only might this earn ranchers payments for sequestering carbon, but increasing the amount of carbon in the soil helps to increase moisture-holding capacity, making ranchers more resilient not only to climate change, but to the natural variations that bring wet and dry years to the Plains. The ranchers started to see themselves as part of the solution--if they were prepared with the right information.

What happens in the Central Great Plains will affect conditions here on the Gulf Coast. What they do and what the climate does will affect river flow in the Mississippi, and will likely affect erosion rates and silt transport. Maybe the changing rainfall and runoff patterns and timing will affect the hypoxia zone, or the supply of silt to barrier islands, or nutrients that affect marine life and coastal estuaries.

It is such questions and issues that need to be explored at this workshop. The workshop is being organized as part of the government's research program. We are not into regulations, but

are into exploring connections and couplings--helping provide the information needed to avoid decisions that might lead to adverse impacts from global change. Our assessment is starting with a regional focus--issues relating to where people live. It is also looking at some key sectors on a national level and will be working to try to provide a national level picture of what the nation's sensitivities and vulnerabilities are to climate change. Our hope is that with information and the involvement of people, organizations, and governments, everyone will be better able to cope with the changes that are coming, and will be able to identify actions that can aid in adaptation to the changes that will be occurring.

Thus, this workshop is really your workshop. We at the federal level are here to be resource people, to ask questions, and to report on lessons from other regions and studies. It is up to you to decide where the discussions go, what the issues are we explore. To advance the National Assessment process, we are asking that the workshop report on its discussions, and, over the next year, we are asking that the network that emerges from this workshop prepare a summary report for yourselves and for the nation that will at least start to answer the "So What" question that members of Congress are asking and that will tell the rest of the nation why what is happening in your region is important to the rest of the nation.

Closing Comments

Let me close with a brief story. Last summer, we asked Virginia Burkett to speak at a monthly seminar the USGCRP sponsors on Capitol Hill. The topic was coastal wetlands, mainly along the Gulf of Mexico. Virginia gave a wonderful talk, describing how this and that barrier island was disappearing or changing. It was fascinating--but it was not quite connecting to the mostly inside-the-Beltway audience. During the question and answer period, I tried asking a question to help make this connection. I asked: "Well, it is all very interesting that barrier islands are disappearing along the Gulf Coast, but I live in Maryland and why should I care?" There was a very brief pause before there was quite an eruption: "Where do you think your shrimp come from?" "Where do you think the Gulf fish come from?" "These islands help defuse hurricane winds--damage will be much greater without them, and your taxes pay for FEMA reimbursements." "Do you know how many people vacation there?" "The Mississippi is a major shipping channel that supports the nation's economy." And on and on--I just sat quietly taking notes--hearing just what I had hoped would be said. This region matters to the rest of the country, and the world, and impacts here will affect us all.

Since I have become involved with the Steering Committee for this workshop, other issues have started emerging: What will be the distributional effects of these consequences across different income groups--across rural and urban dwellers, and so on? What unique issues arise because New Orleans is below sea level? Etc.?

Climate change will be important not only for you, but also for the country. We want the discussions that begin here to seek to understand what these changes will be, how important they will be, and to start to explore how to plan for the future in ways that will accommodate climate change.

This work was performed under the auspices of the U.S. Department of Energy at LLNL under contract no. W-7405-Eng-48.

Captions

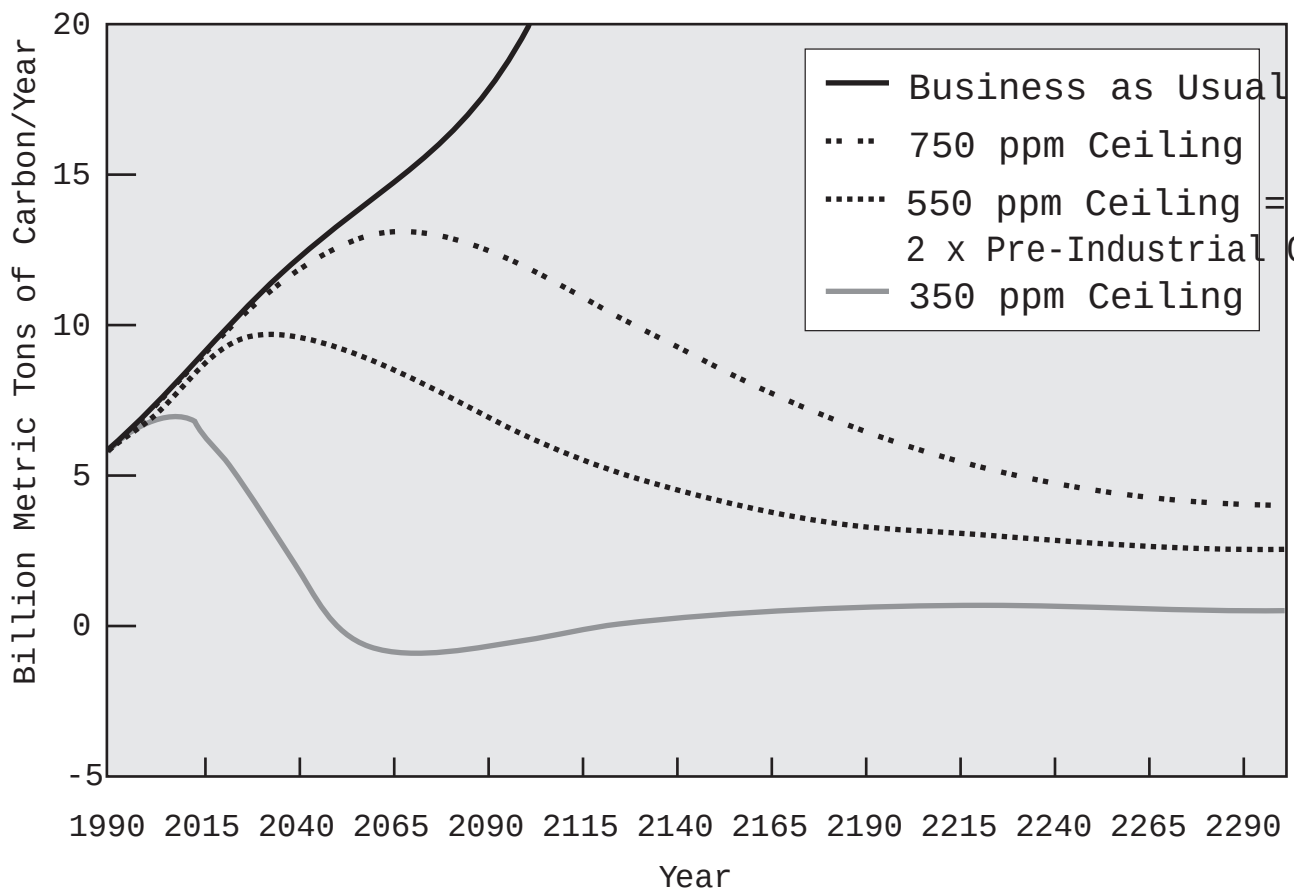
Figure 1: The CO_2 concentration has risen from about 275 ppmv prior to the Industrial Revolution to a level of about 370 ppmv today. This increase has occurred as a result of emissions from fossil fuel combustion, deforestation, and carbon release from soils caused by agriculture.

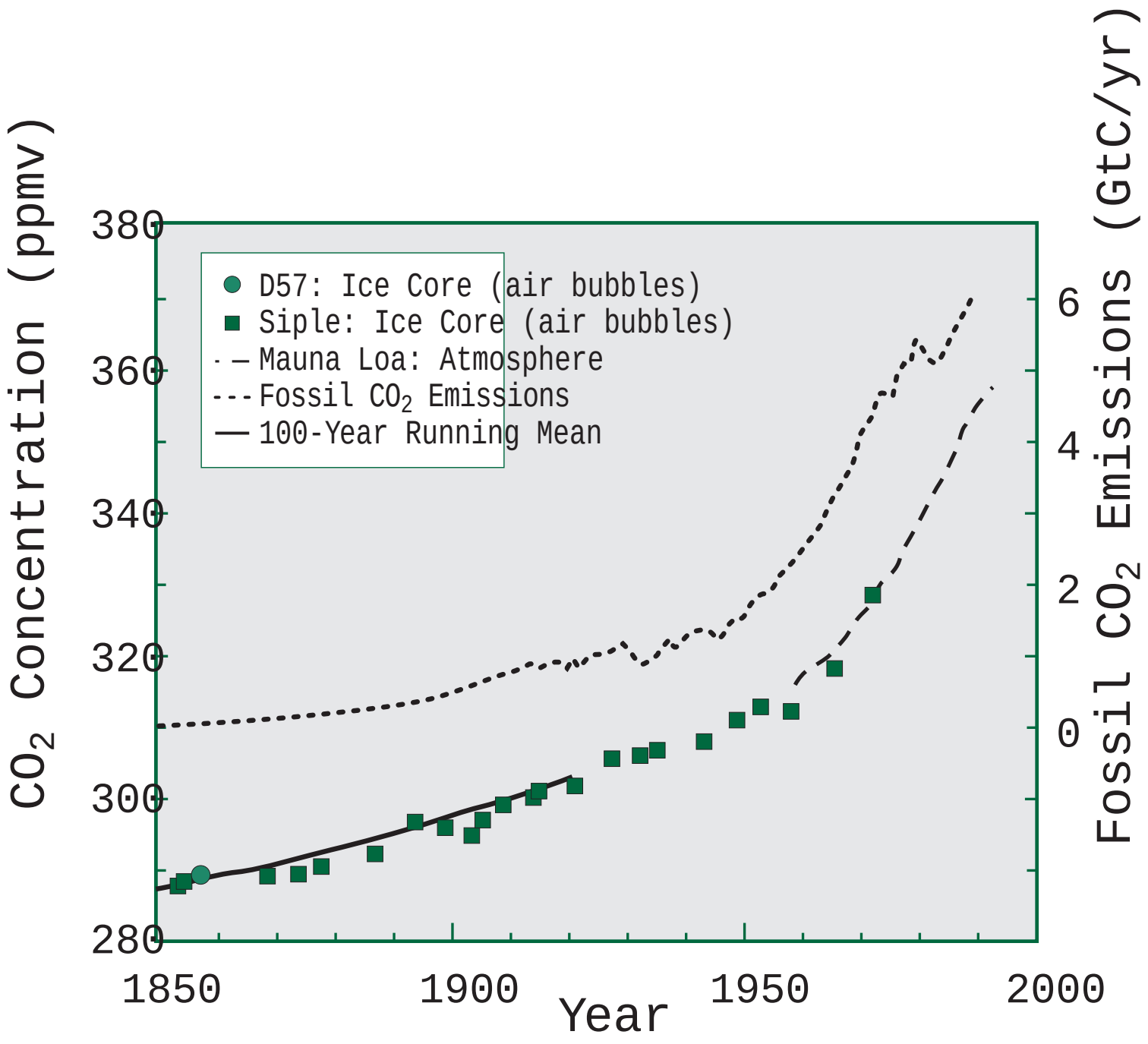
Figure 2: Record of CO_2 concentration and temperature from the Vostok ice core in Antarctica and extended to the present. There is a close association between the CO_2 and temperature changes, with the variations in CO_2 apparently amplifying temperature changes initiated by cyclic changes in the Earth's orbit around the Sun.

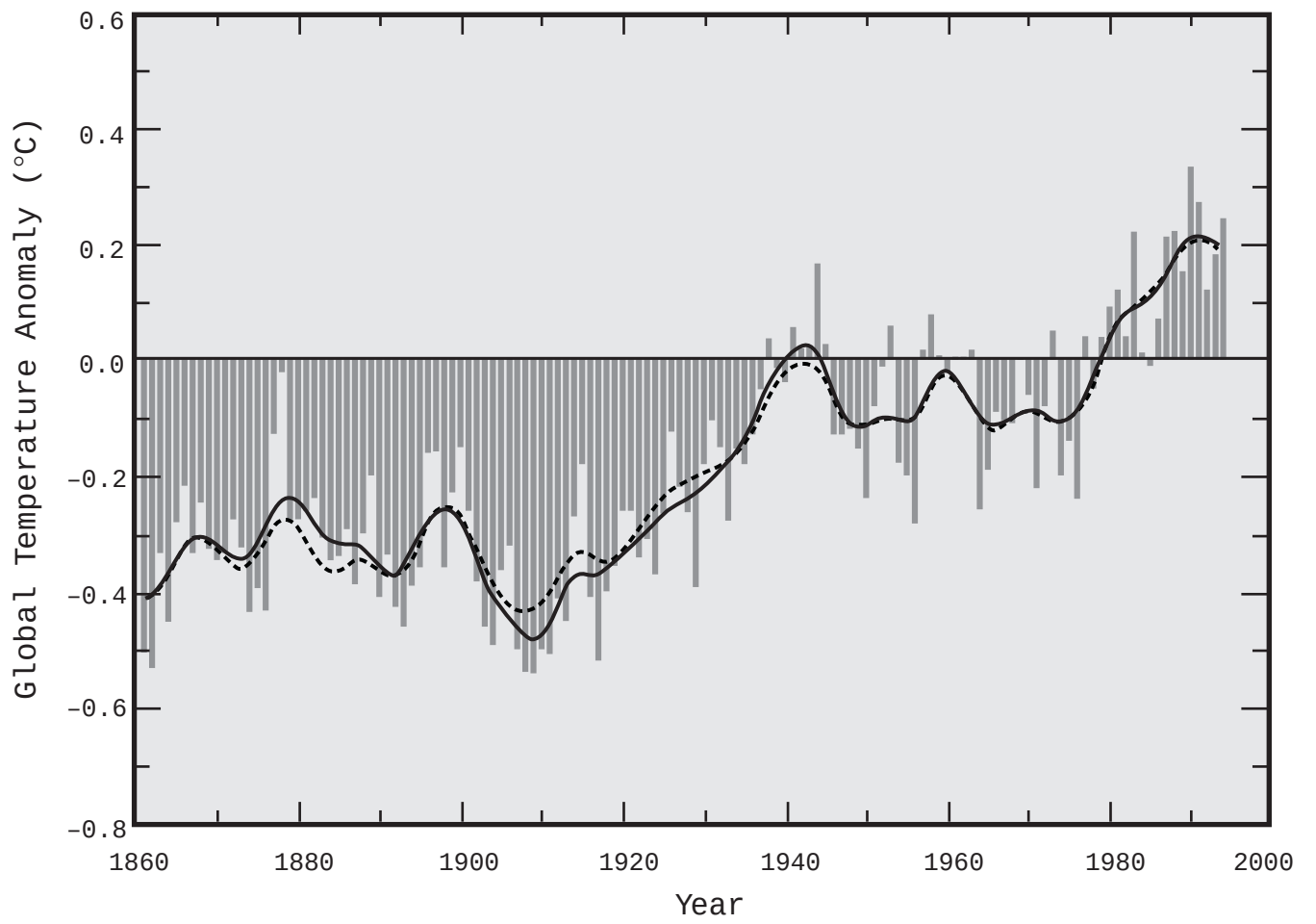
Figure 3: Global temperature record from 1860 to the present, showing a warming of about 0.5^{o} C (1^{o} F) over the last century.

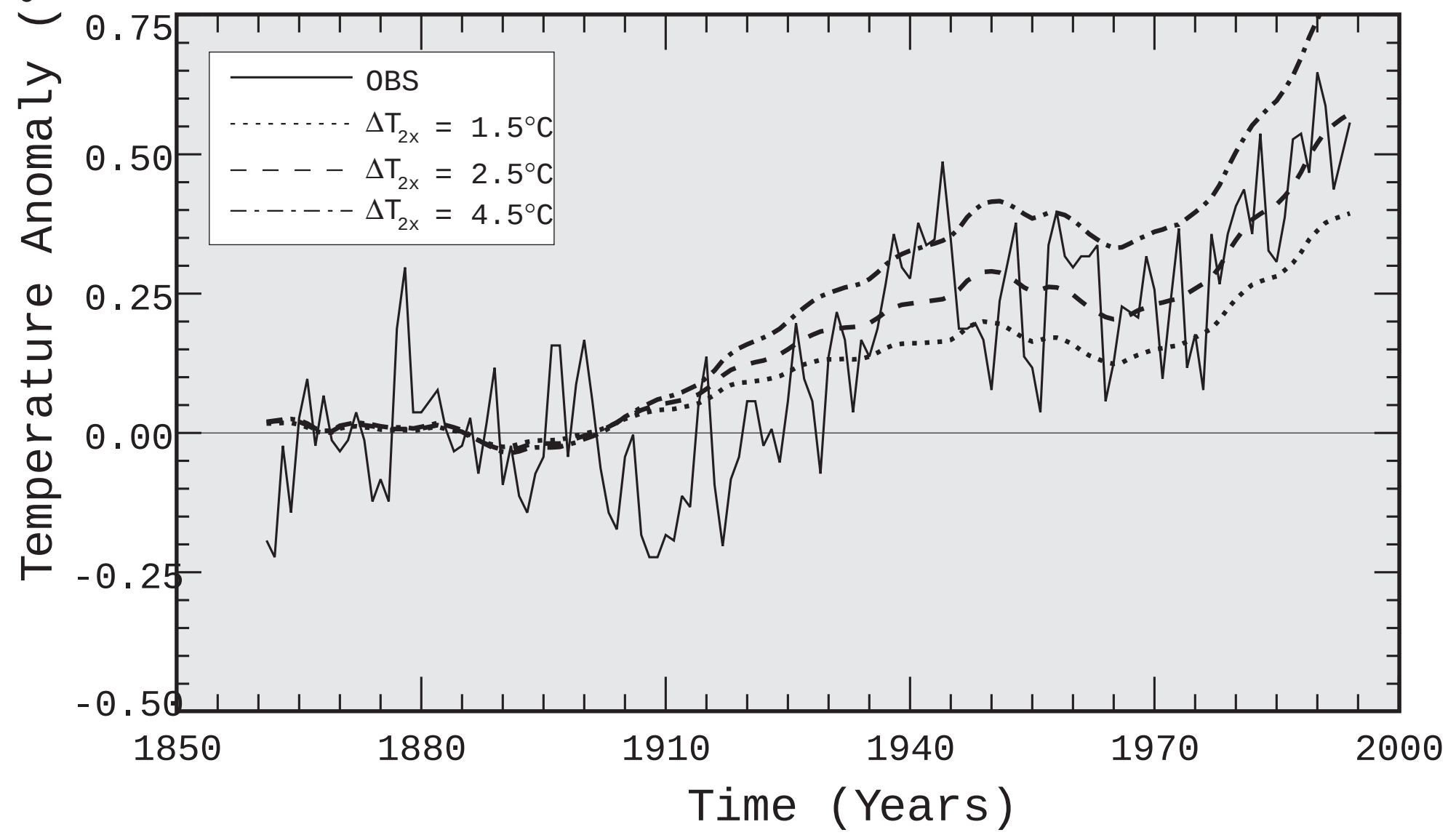
Figure 4: The observed temperature record and climate model simulations incorporating observed and reconstructed changes in greenhouse gases, aerosols, and solar radiation (from Wigley)

Figure 5: Stabilizing the concentration of CO_2 in the atmosphere will require significant cutbacks in emissions from projections of the emissions rate assuming Business-as-Usual.


Billion Metric Tons of Carbon/Year
20
15
10
5
0
-5
1990
2015
2040
2065
2090
2115
2140
2165
2190
2215
2240
2265
2290
Year
Business as Usual
750 ppm Ceiling
550 ppm Ceiling =
2 x Pre-Industrial
350 ppm Ceiling


D57: Ice Core (air bubbles)
Siple: Ice Core (air bubbles)
Mauna Loa: Atmosphere
Fossil CO2 Emissions
100-Year Running Mean
CO2 Concentration (ppmv)
Fossil CO2 Emissions (GtC/yr)
Year
280
300
320
340
360
380
0
2
4
6
1850
1900
1950
2000


Global Temperature Anomaly (°C)
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
1860
1880
1900
1920
1940
1960
1980
2000
Year


OBS
ΔT2x = 1.5°C
ΔT2x = 2.5°C
ΔT2x = 4.5°C
Temperature Anomaly (°
0.75
0.50
0.25
0.00
-0.25
-0.50
1850
1880
1910
1940
1970
2000
Time (Years)


Temperature Variations (°C)
+4
+2
0
-2
-4
-6
-8
-10
450
400
350
300
250
200
CO_2 Concentration (ppmv)
Observed
Other Ice
Core Records
Vostok Ice Core
Reconstruction
Measurements
and Projections
150,000
100,000
50,000
0
1850
2100
Years Ago
Years A.D.