'97 OCT 3 AM5:46

Wh conf "Visuals

Todd,

Attached is the latest science "script" with figures included. In most cases, they are very rough approximations of what the finshed product will look like, but they will give you a good idea of what is planned (in a few cases, we are making brand new figures and don't even have rough drafts yet). The closest to final in appearance and color scheme are the ones cut out of our "State of Knowledge" Booklet. I should the first batch of high quality, near-final figures tomorrow, and I'll make sure you get a copy ASAP.

We expect some modification from Waton and Holdren of text, and pssibly figures tomorrow morning.

I also attached a couple of examples of the kind of pie charts we expect from DOE. We should get the real thing from them tomorrow.

We look forward to getting your comments and finishing this up.

Peter B

OSTP Science Presentation Script

Format: 2 screen slide show, with selected change images fading into one another.

Climate Science Overview - John Holdren, Harvard University

Introduction: There is a strong scientific consensus that the climate is changing, that human activities are among the most significant causes of this change, and that the consequences of this change are likely to include a variety of negative impacts on human health and well being and on the environment. I'm going to spend a few minutes explaining how the climate system works, how it is changing, and how this change is likely to affect our nation. The data I will present is drawn mostly from the Intergovernmental Panel on Climate Change (IPCC), which is the most comprehensive and authoritative source of information on climate change. The IPCC process includes more than 2000 of the world's leading climate scientists from more than 50 countries. I've also included some scientific findings that have been published since the last IPCC report. I want to emphasize that all of the science is drawn from the peer-reviewed literature.

1. The Greenhouse Effect and Greenhouse Gas Emissions: There is a natural greenhouse effect that keeps the Earth about 33 degrees C, or 60 degrees F, warmer than it would be. Without this effect, life would not be possible. The Earth both absorbs and reflects incoming solar radiation. Water vapor, CO2, methane, nitrous oxide, and other trace gases act something like a blanket, trapping heat as it is re-radiated out to space.

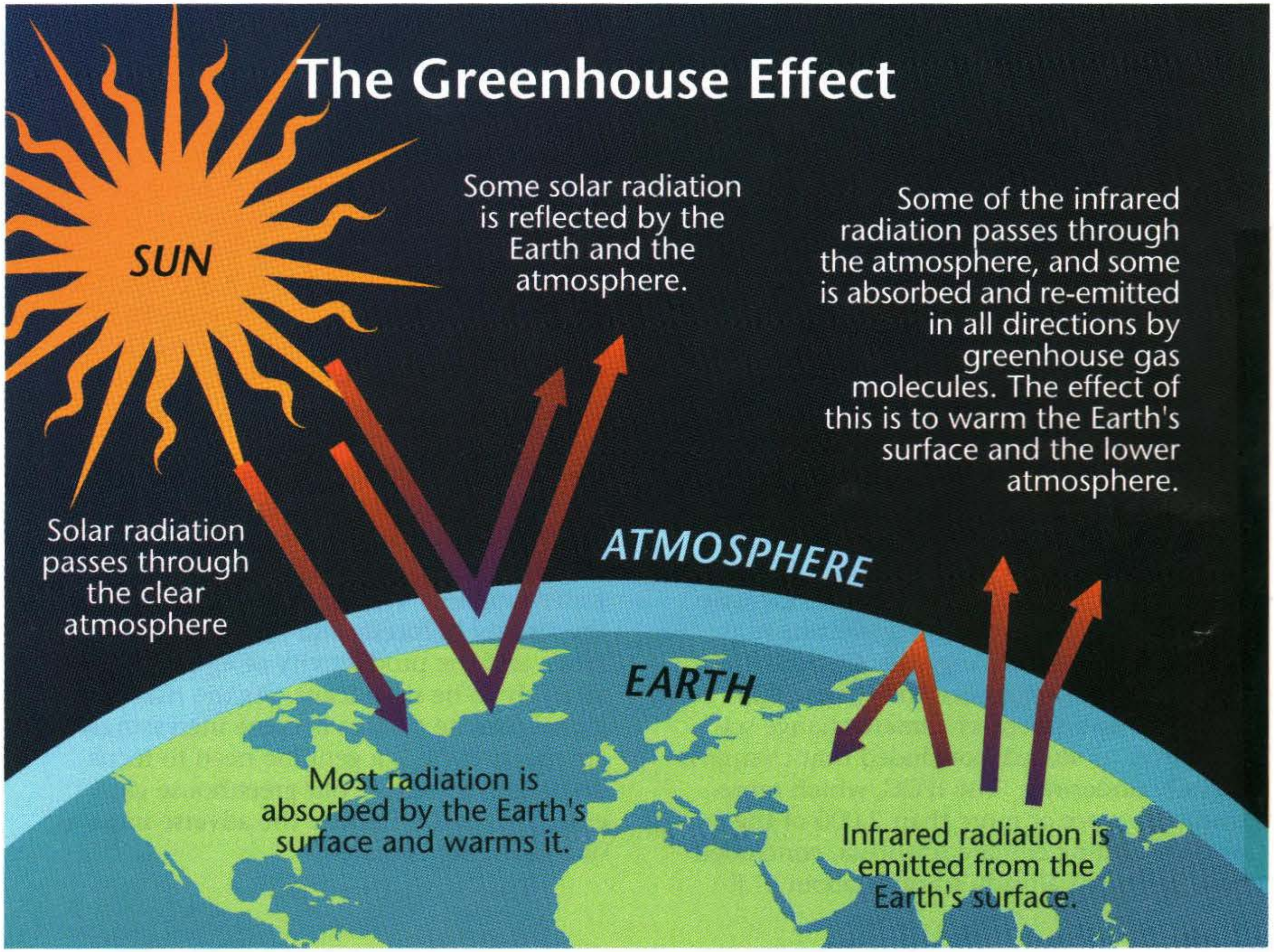
Since pre-industrial times, humans have added to the natural greenhouse effect by releasing additional greenhouse gases into the atmosphere. Burning of fossil fuels for energy is the primary source of emissions (about 6 billion metric tons of carbon per year); changing land-use patterns through agriculture and deforestation also contribute another 1-2 billion metric tons per year. Since the Industrial Revolution, atmospheric concentrations of carbon dioxide -- the most important greenhouse gas -- have increased about 30%, from 280 to 360 parts per million by volume (ppm). Other greenhouse gases have also increased.

Visual: **Screen 1: Greenhouse effect slide** 1
Screen 2: CO2 emissions and concentrations together since 1860. 2

2. Whose emissions are in the atmosphere now? And whose emissions will be in the atmosphere in the future? Today, developed countries account for most of the concentrations in the atmosphere. The U.S., which has 4% of the world's population, is responsible for more than 25% of the greenhouse gases emitted into the atmosphere over the past 40 years. Developing countries, with 80% of the current world population, accounted for less than a quarter of the past four decade's emissions. Their per capita emissions average about 1/10 to 1/20th of ours. In the US, industry, transportation, and commercial and residential buildings each account for about 1/3 of the emissions total.

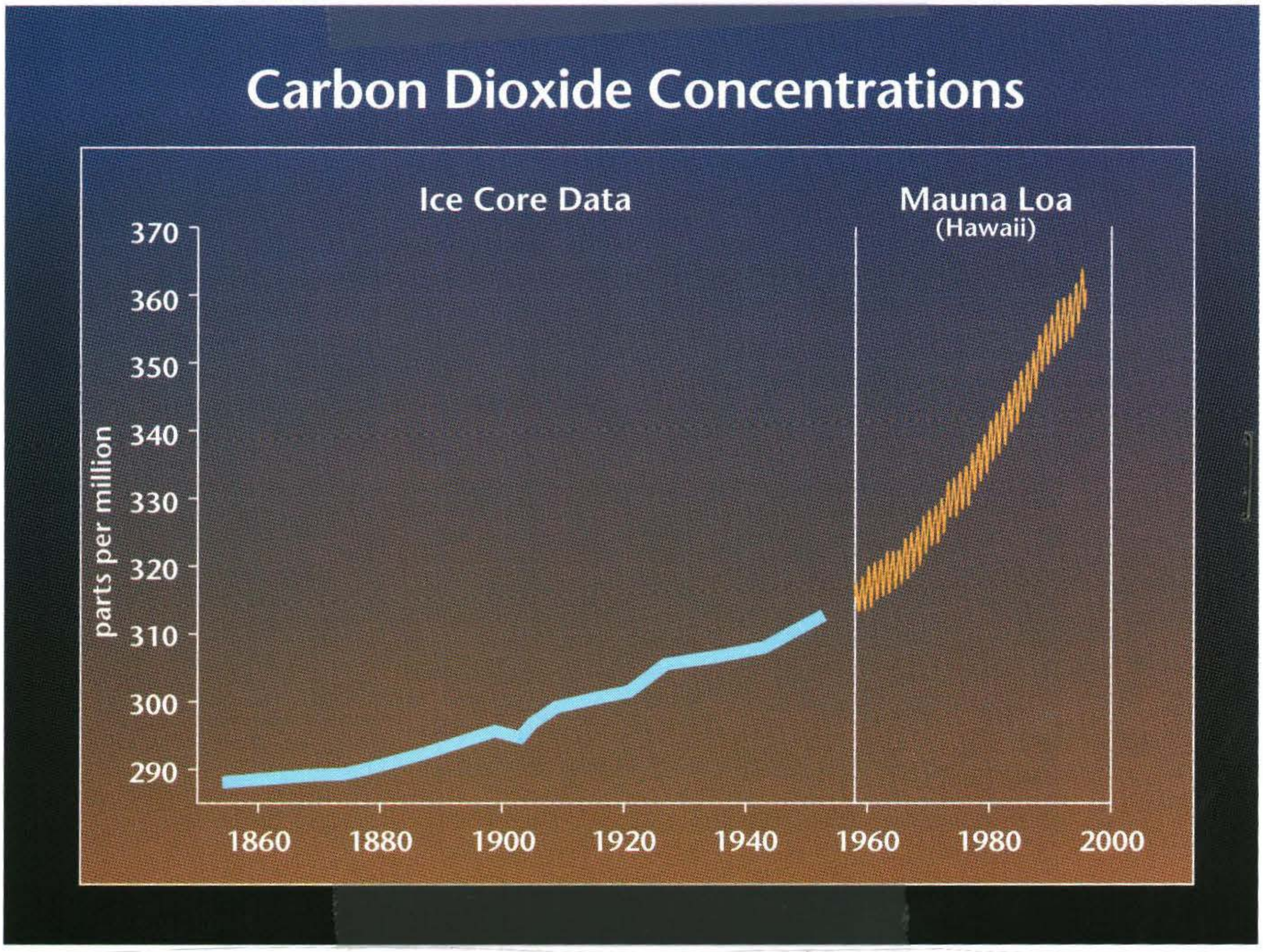
90% of the world's population growth over the next few decades will take place in developing countries. Their emissions of greenhouse gases will most certainly increase as energy use grows over the next few decades. (For example, there is only 1 car per 2,000 people in China). Over the next century, under "business as usual", we expect emissions from the developing countries (top 5 bands) to rapidly increase, equaling those of Annex 1 (US, OECD, former Soviet Union, and Eastern Europe—lower 4 bands) by about 2035 and continue to climb.

Visuals **Screen 1: CO2 Emissions, 1950 to 2100 (Developed and Developing World)** 3
Screen 2: Present Per capita carbon emissions 4


The Greenhouse Effect
SUN
Some solar radiation is reflected by the Earth and the atmosphere.
Some of the infrared radiation passes through the atmosphere, and some is absorbed and re-emitted in all directions by greenhouse gas molecules. The effect of this is to warm the Earth's surface and the lower atmosphere.
Solar radiation passes through the clear atmosphere
ATMOSPHERE
EARTH
Most radiation is absorbed by the Earth's surface and warms it.
Infrared radiation is emitted from the Earth's surface.

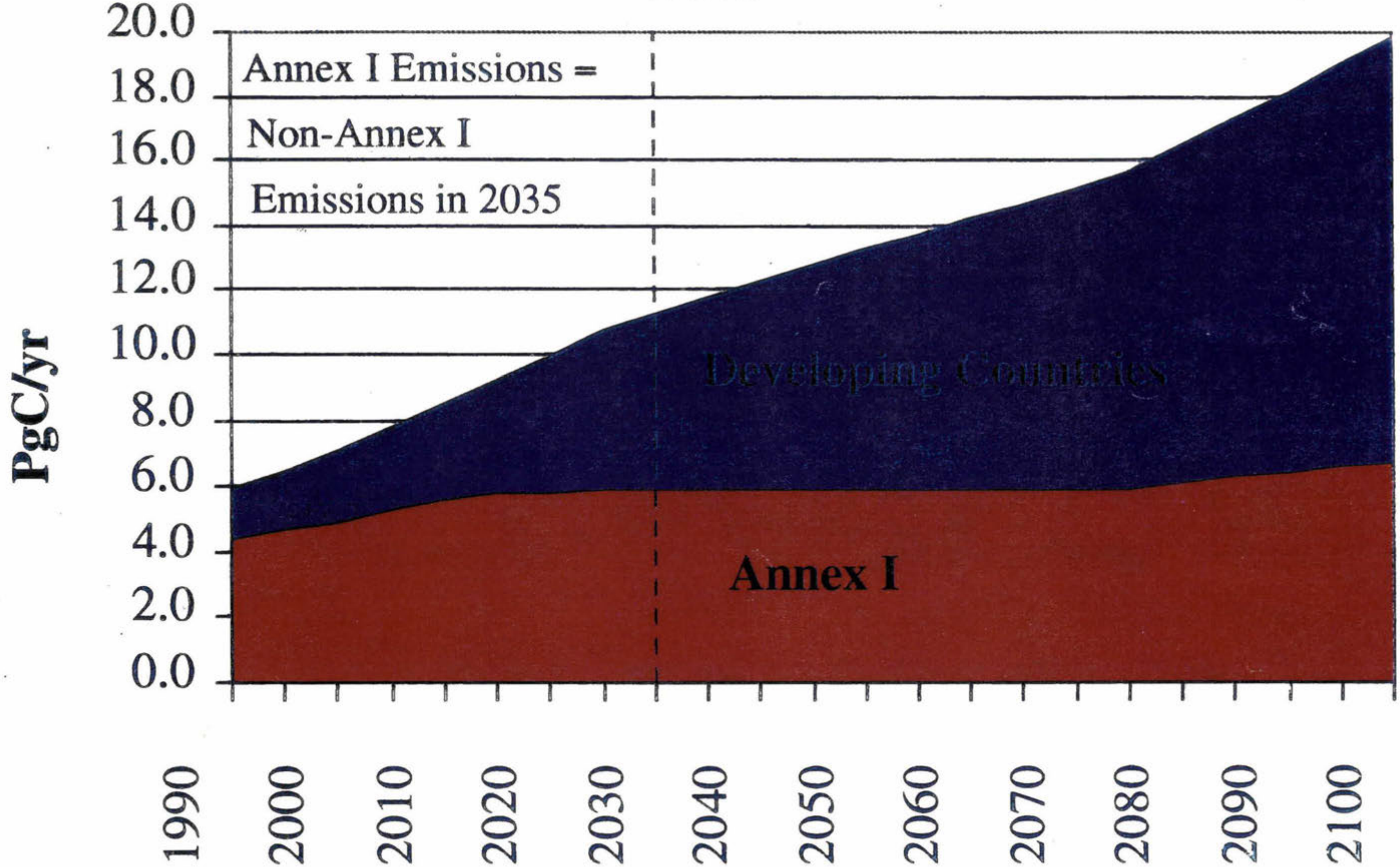
2

But emissions line will be added

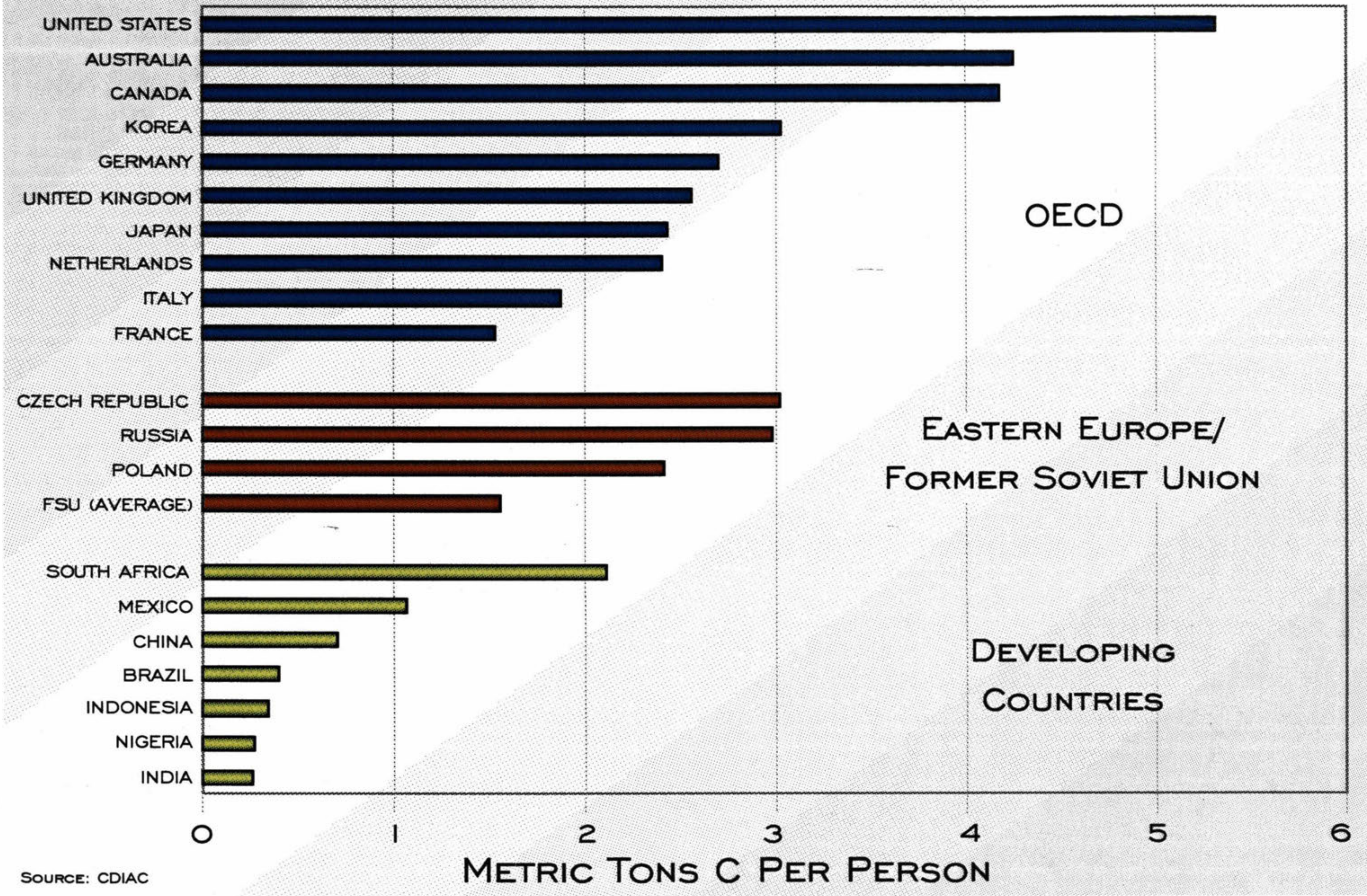


③
But extended back in time

Annex I and Non-Annex I Fossil Fuel Carbon Emissions: BAU



PER CAPITA CARBON EMISSIONS



SOURCE: CDIAC

3. What has happened over the last 100 years as CO_2 concentrations have risen? Over the last century, the global mean surface temperature increased by almost 1.0 degree F. The surface temperature this century is as warm or warmer than any century since at least 1400 AD. The last few decades have been the warmest this century. The 11 warmest years this century have all occurred since 1980, and 1995 was the warmest year on record. It also appears that precipitation is increasing in many regions of the world, although there is a lack of data over the ocean. In addition to the direct measurements of temperature and precipitation, there is additional evidence that the climate is changing. Sea level has risen, permafrost is warming, and alpine glaciers are melting worldwide. The glaciers of Glacier National Park have receded steadily for decades. By 1993, there had been a 73% reduction in the area of eight prominent glaciers in the Park. Model projections indicate that all the Park's glaciers will disappear by 2030 unless temperatures begin to cool instead of continue to warm.

Visuals **Screen 1: Global Temperature, 1860 to Present** 5
Screen 2: Glaciers melting -- Historic and present-day photographs. 6

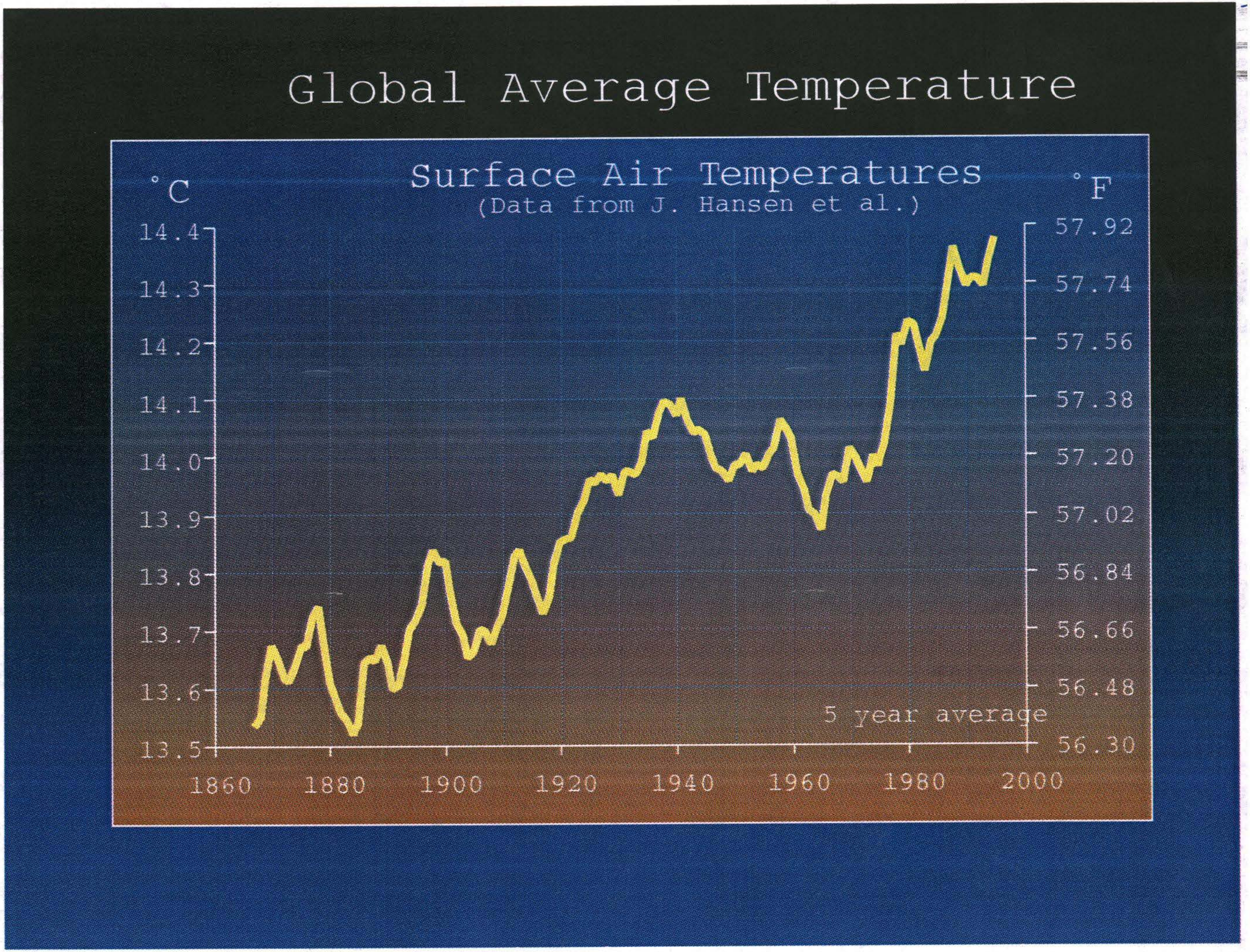
4. Where are we headed? Under a range of plausible IPCC scenarios for emissions, to atmospheric concentrations of over 700 ppm of CO_2, and another 2-6 degrees F by 2100. Let me put this in perspective by showing CO_2 and temperature change over the last 160,000 years. We are already outside of the natural range of CO_2 concentrations and by 2100 we will experience the highest levels since 50 million years ago. We will be headed for triple the pre-industrial concentrations, and we will have achieved this in a geological blink of an eye, at a much faster rate of change than what natural systems have been exposed to in the last 10,000 years. And we will still be climbing.

Visuals **Screen 1: Projection of CO_2 and Temperature Range to 2100 for Business As Usual** 7
Screen 2: CO_2 and Temperature Over the Last 170,000 Years (VP chart) 8

5. The consequences of such increases go beyond temperature. Warming the ocean causes sea-level to rise -- mostly from thermal expansion of water, some from melting of sea ice and glaciers. The thermal inertia of the ocean means this will continue for several centuries after greenhouse gas concentrations stabilize. Warming also causes the planet's hydrological cycle to speed up. There is more evaporation, meaning there is more water in the atmosphere that will come down as rain or snow. The increased evaporation will also lead to drying in some areas, so we expect <u>both</u> more soil drying and more precipitation. These shifts in temperature, precipitation, and sea-level rise will impact many aspects of our lives: including worsening health effects of poor air quality, shifting agricultural yields, eroding beaches, inundating coastal lands, and causing the range of many plant and animal species to shift significantly.

Visual: **Screen 1: Sea-level rise: time-line and levels (from IPCC SAR)** 9
Screen 2: World sea rise: area and populations at risk 10

Visual: **Screen 1: Hydrological Cycle Diagram** 11
Screen 2: World Agriculture map 12


Global Average Temperature
Surface Air Temperatures
(Data from J. Hansen et al.)
°C
°F
14.4
14.3
14.2
14.1
14.0
13.9
13.8
13.7
13.6
13.5
57.92
57.74
57.56
57.38
57.20
57.02
56.84
56.66
56.48
56.30
5 year average
1860
1880
1900
1920
1940
1960
1980
2000

6

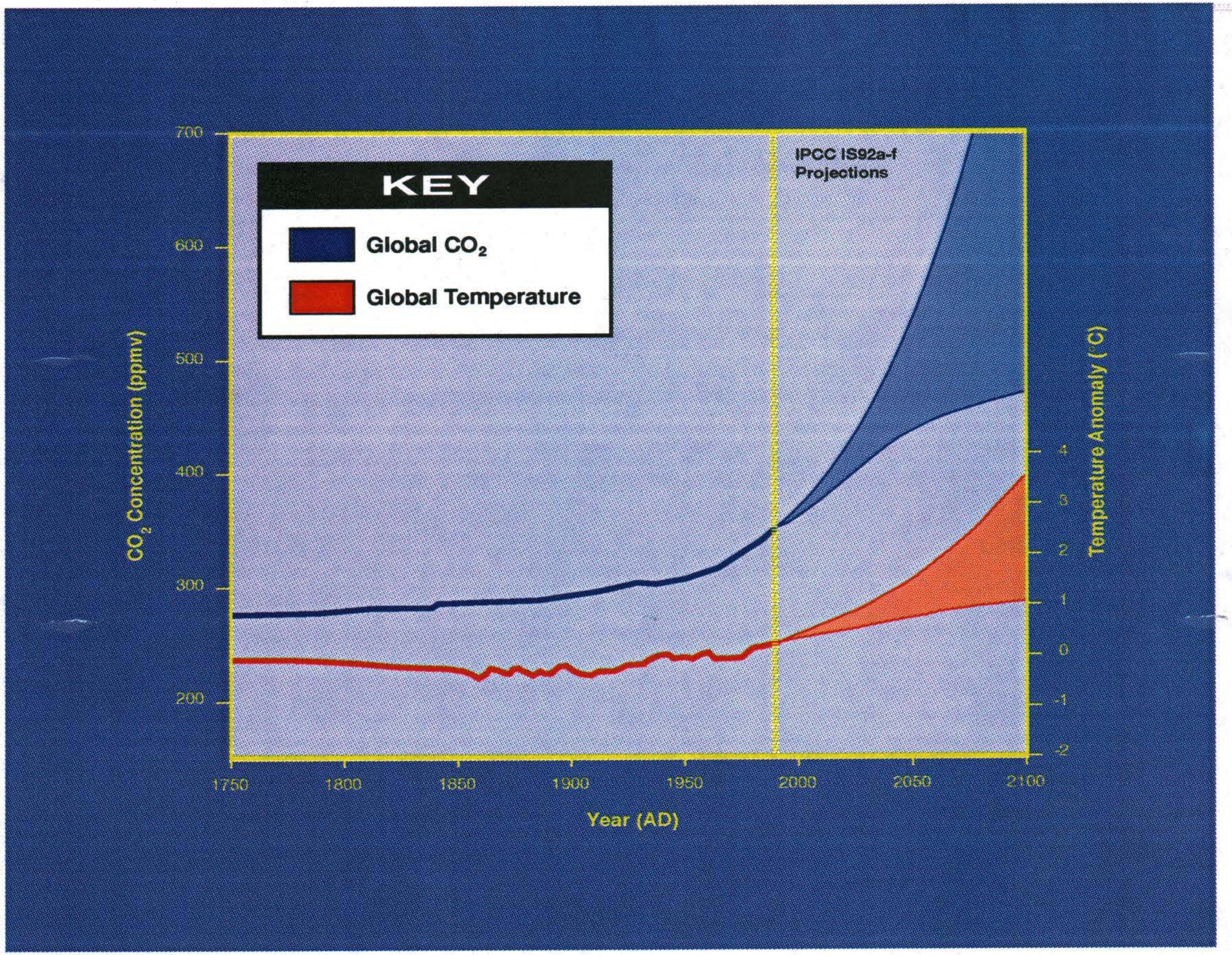
Ice Cave, Boulder Glacier, July 1932

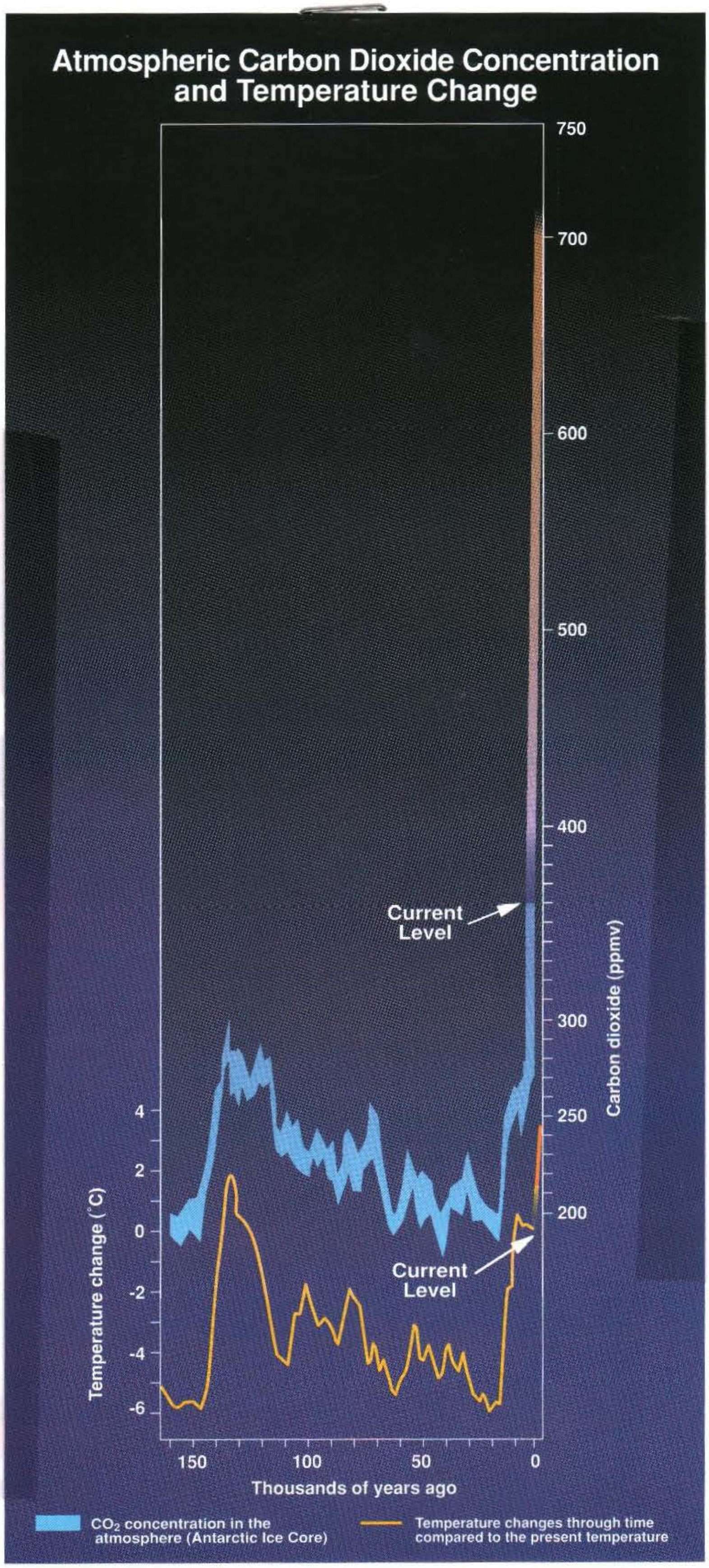
George Grant photo, GNP

Same photo point as above, 1988

Jerry DeSanto photo

7


KEY
Global CO_2
Global Temperature
IPCC IS92a-f Projections
CO_2 Concentration (ppmv)
Temperature Anomaly (°C)
Year (AD)
700
600
500
400
300
200
4
3
2
1
0
-1
-2
1750
1800
1850
1900
1950
2000
2050
2100



Atmospheric Carbon Dioxide Concentration and Temperature Change
750
700
600
500
400
300
250
200
Carbon dioxide (ppmv)
Current Level
Current Level
4
2
0
-2
-4
-6
Temperature change (°C)
150
100
50
0
Thousands of years ago
CO2 concentration in the atmosphere (Antarctic Ice Core)
Temperature changes through time compared to the present temperature

(8)

9

New Figure

Not Yet Completed

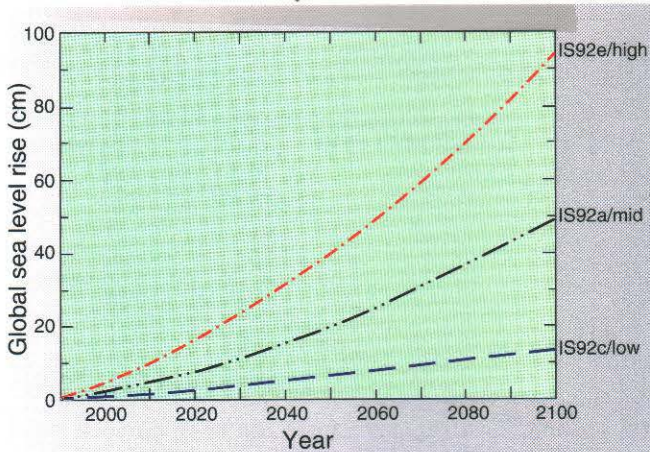
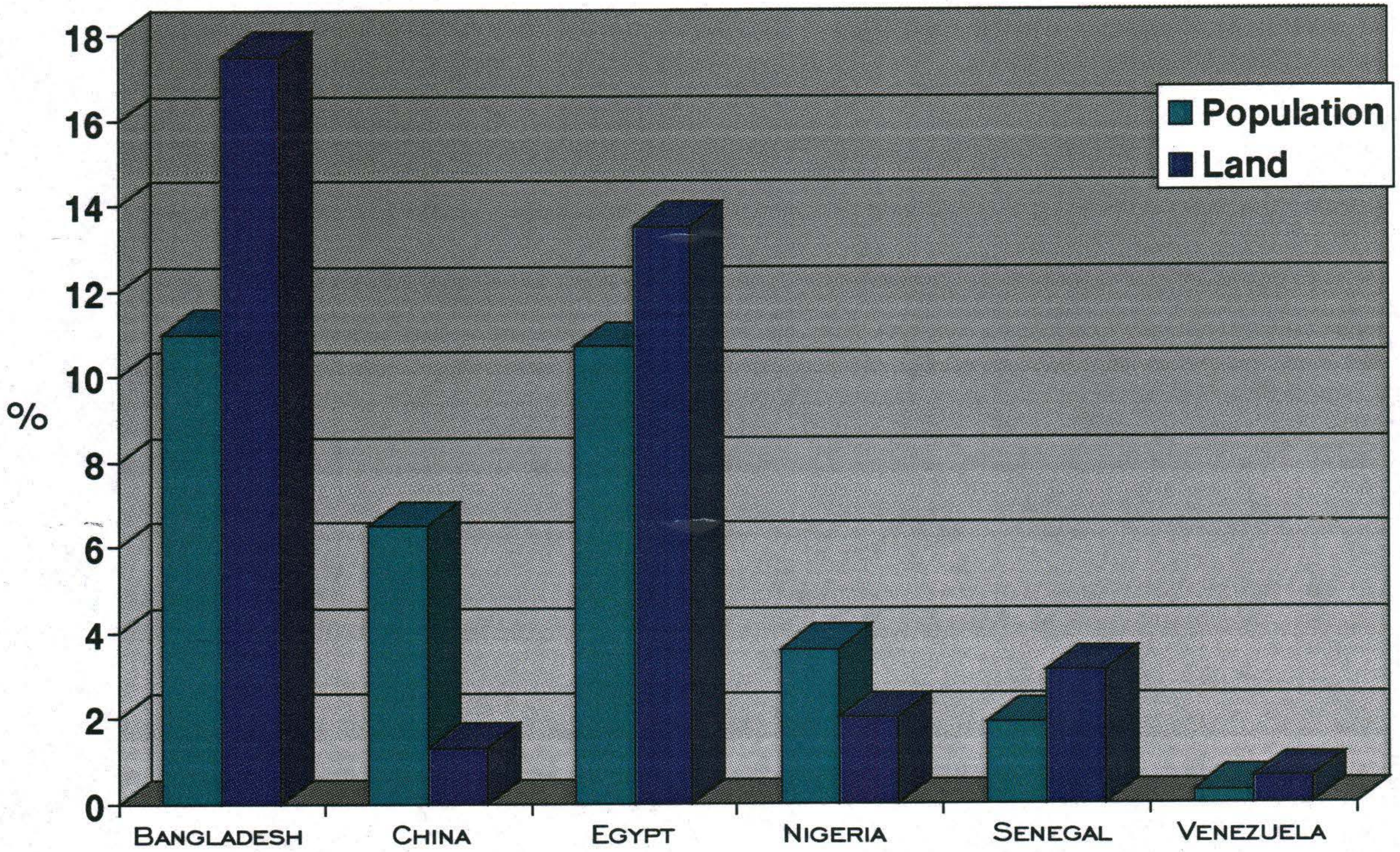


Figure 21: Projected global mean sea level rise extremes from 1990 to 2100. The highest sea level rise curve assumes a climate sensitivity of 4.5°C, high ice melt parameters and the IS92e emission scenario; the lowest a climate sensitivity of 1.5°C, low ice melt parameters and the IS92c emission scenario and the middle curves a climate sensitivity of 2.5°C, mid-value ice melt parameters and the IS92a Scenario.

Coastal Resources: International Lands and Populations at Risk from a 1 Meter Sea Level Rise

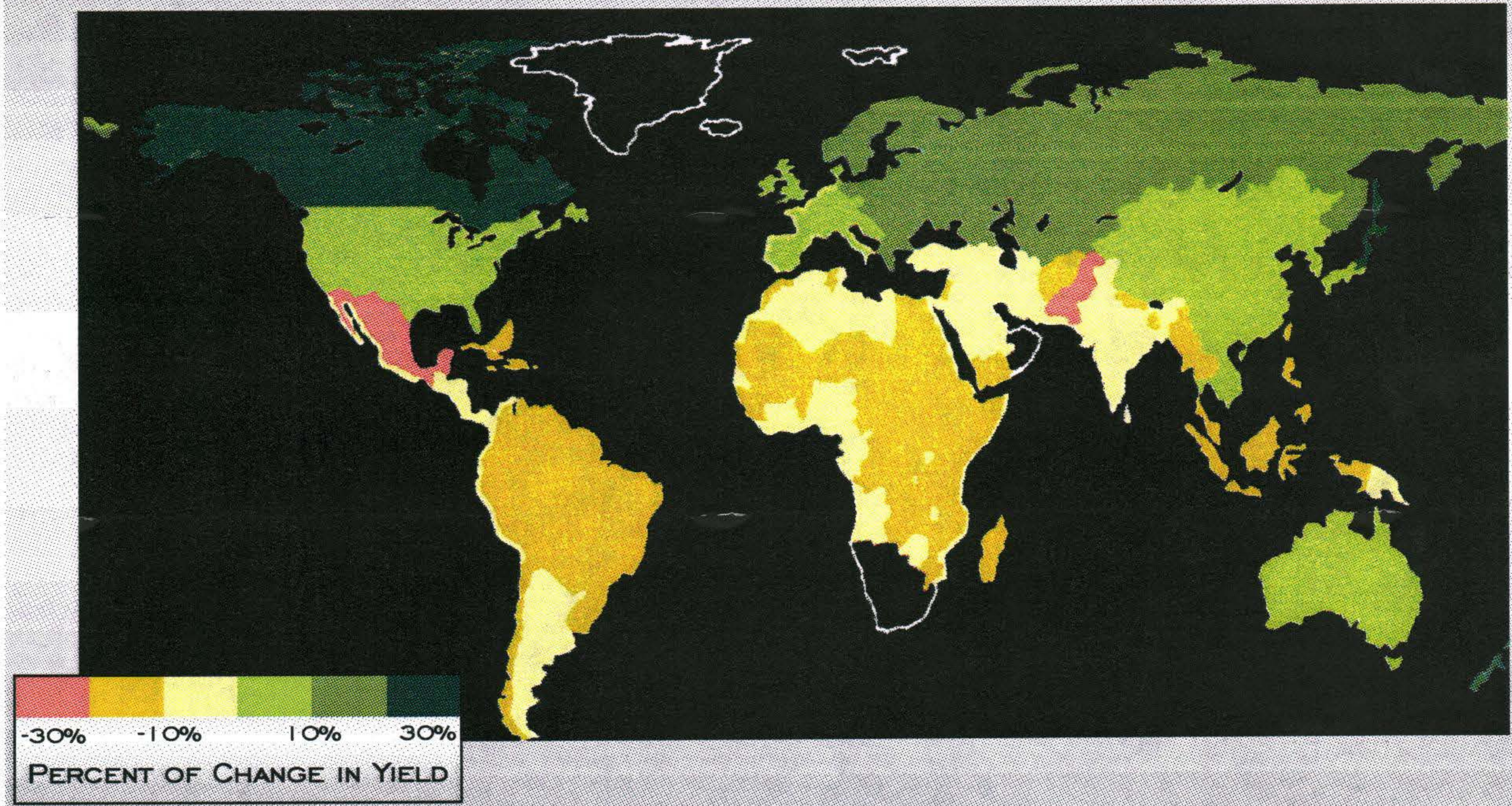


Source: Strzepek and Smith (1995)

11

New
Figure
Not Yet Completed

Agricultural Resources: Potential Change in Grain Yield due to Doubled CO_2



Based on GISS model; physiological CO_2 effects included

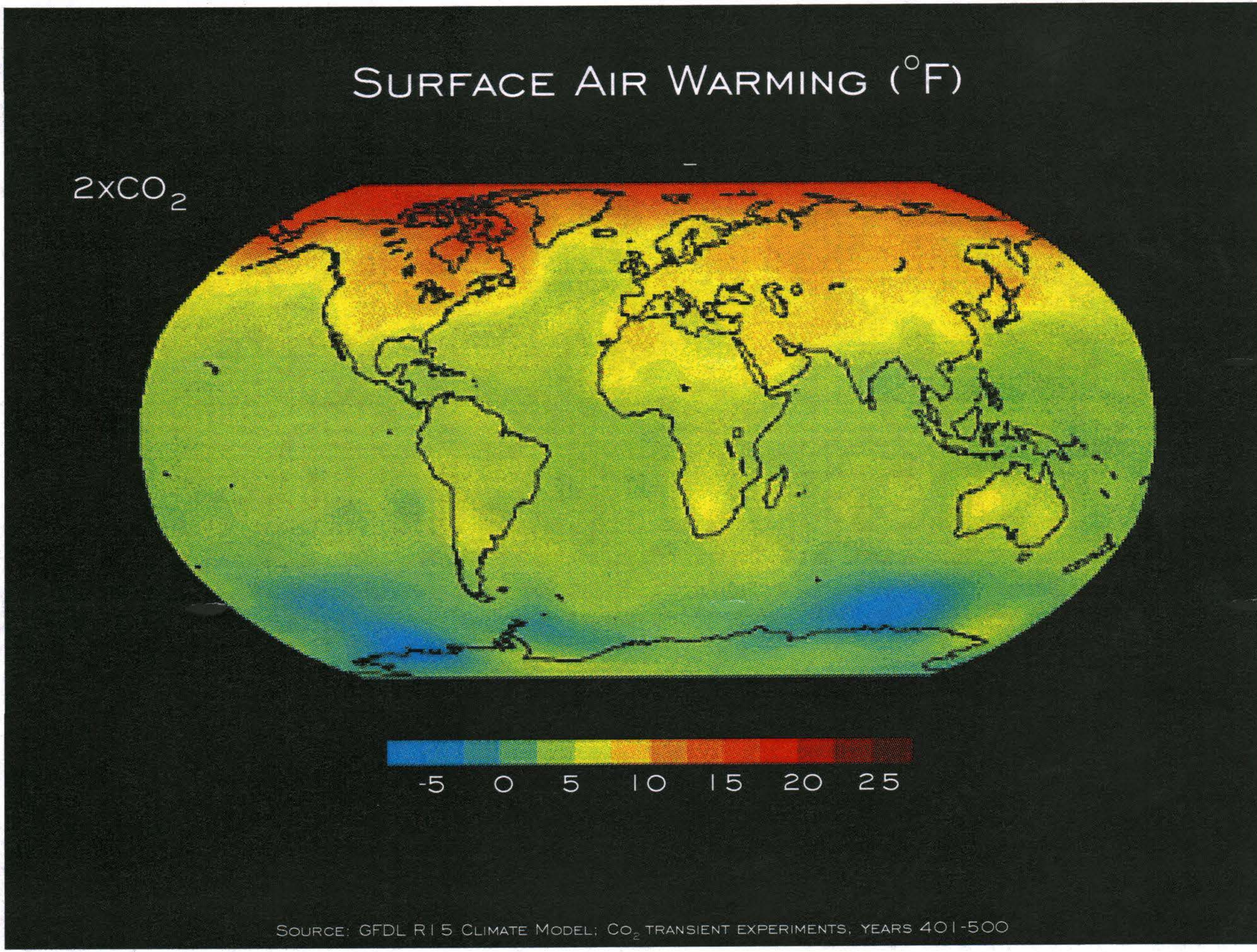
Source: Rosenzweig and Hillel (1993)

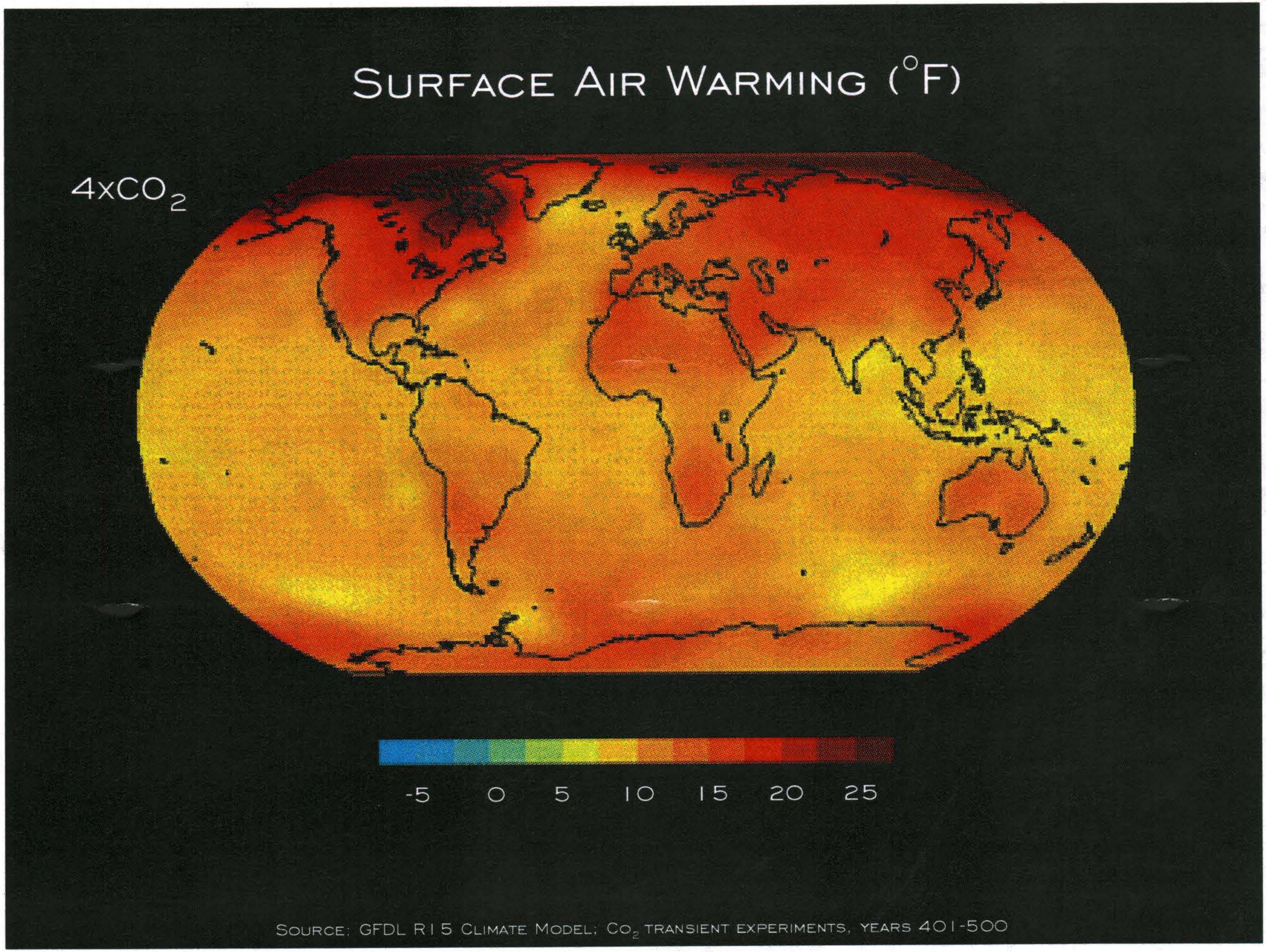
6. Most impacts research has only evaluated the effects of a doubled CO2 world at equilibrium. Current emissions/concentration trajectories, such as those I just showed you, indicate that we cannot ignore the possibility of concentrations that far exceed doubling, or even tripling. We must begin to understand what impacts of such concentrations might be. We don't yet know exactly what this would mean for human health and ecosystems in our country, but we have some initial results of how some physical climate parameters might change. I'd like to close by showing you some model projections for the US that show how average temperature increases. This video clip shows changes from now to a 2 times CO2 world over 200 years, and as you can see the effects are quite dramatic, with increases of 5 to 10 degrees F in North America (warming is greater at higher latitudes). The next sequence is from now to a 4 times CO2 world over 200 years, and the warming is in the range of 15 to 20 degrees F. In the growing season, soil moisture deficits would approach 30-50% for quadrupling, as opposed to 10 to 30% for doubling. Avoiding such change is clearly in our national interest.

Visual **Screen 1: Short (20 second) video visualization of North American Temperatures in a 2xCO2 world,** 13
Screen 2: Short (20 second) video visualization of North American Temperatures in a 4xCO2 world. 14

These will be short videos showing change over time

13


SURFACE AIR WARMING (°F)
2xCO2
-5 0 5 10 15 20 25
SOURCE: GFDL R15 CLIMATE MODEL; CO2 TRANSIENT EXPERIMENTS, YEARS 401-500


SURFACE AIR WARMING (°F)
4xCO2
-5 0 5 10 15 20 25
SOURCE: GFDL R15 CLIMATE MODEL; CO2 TRANSIENT EXPERIMENTS, YEARS 401-500

Observed Changes in Climate, Weather, and Extreme Weather Events: Tom Karl, NOAA

Introduction:

Over the past century, temperatures have increased on a global basis about 1 degree F, with significantly larger increases in some regions, including much of the U.S. These temperature changes have begun to produce the kinds of effects that would be expected with warming, including changes in the distribution, amount, and intensity of precipitation.

- If we look at the record of the last century, we can see increased moisture over North America in the form of increases in precipitation.

- In the United States, precipitation has increased an average of 8% since the turn of the century, which brought us an amount of additional water equivalent to the annual discharge of the Mississippi River.

- In 1996 alone, five states set all-time high records for annual precipitation. In many parts of the U.S., the increases have been several times greater than the average of 8%.

Visuals **Screen 1: US Precipitation Increase Time Series** 15
Screen 2: Distribution of US Precipitation Increases 16

But it isn't only overall precipitation that is increasing. The extra energy from an enhanced greenhouse effect can do two things. It can increase the temperature of the atmosphere, which increases its water holding capacity. Or, where water is available, the heat energy can evaporate water, which is, in fact, where much of this extra energy goes.

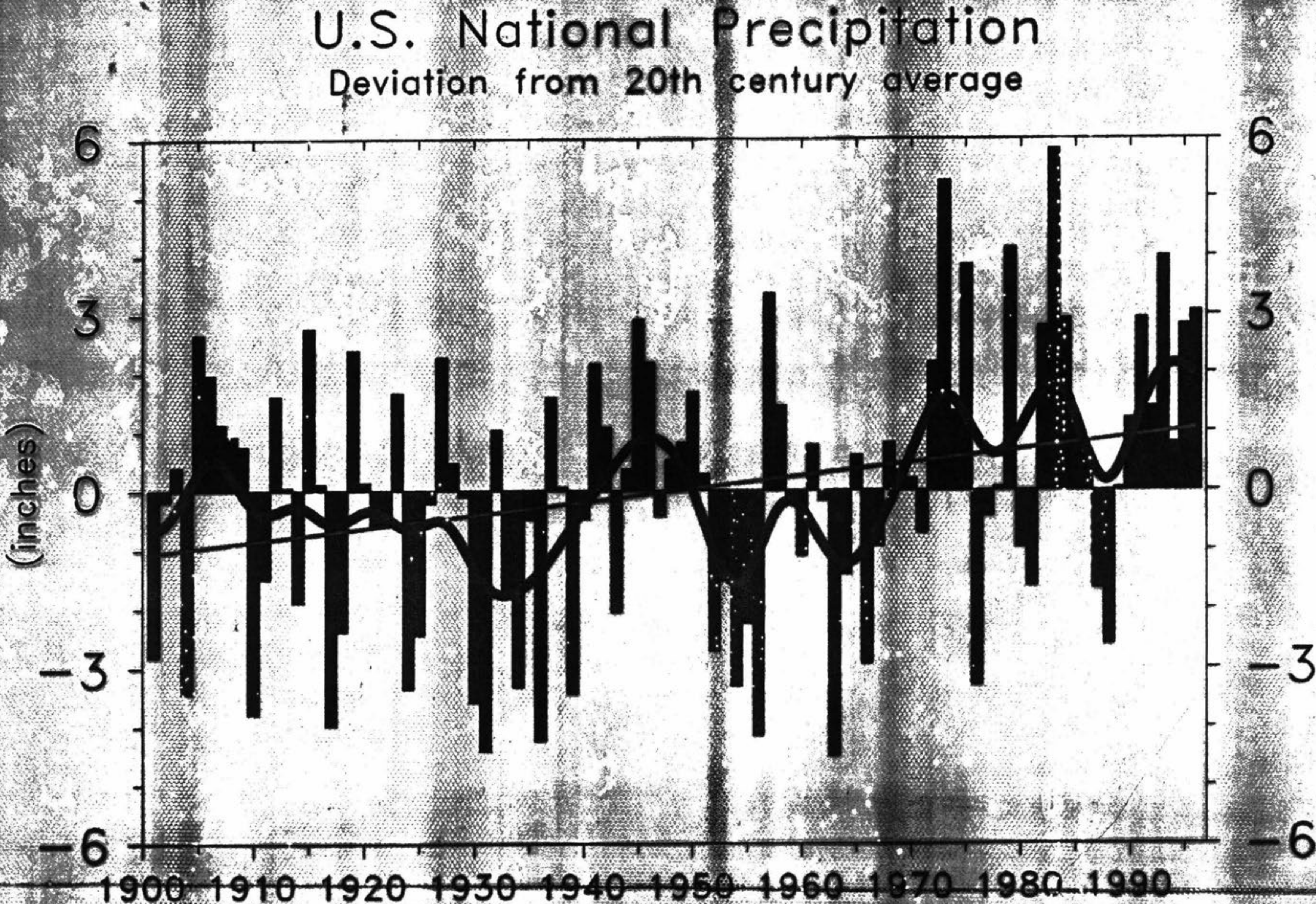
- This increases the water content of the atmosphere, and, in general, produces enhanced amounts and rates of precipitation. In addition, because storms feed on energy and atmospheric moisture, storm duration and size is increased. On the ground, there is likely to be increased runoff and flooding.

- This can also be seen in the climate record, where we have more precipitation falling in extreme events of more than 2 inches in a 24 hour period. These events have increased by 20% in the last century.

Visuals **Screen 1: Flow Chart of Excited Water Cycle** 17
Screen 2: Extreme precipitation In the US Chart 18

- The statistics are an example of the kinds of change we project will intensify in the future. We can't point to any single extreme weather event today and say it was caused by climate change. But we can say that these events are examples of the kinds of impacts we can expect to occur with greater frequency. There will be more "100-year floods," and "100-year storms," and we all know that these events have serious consequences:

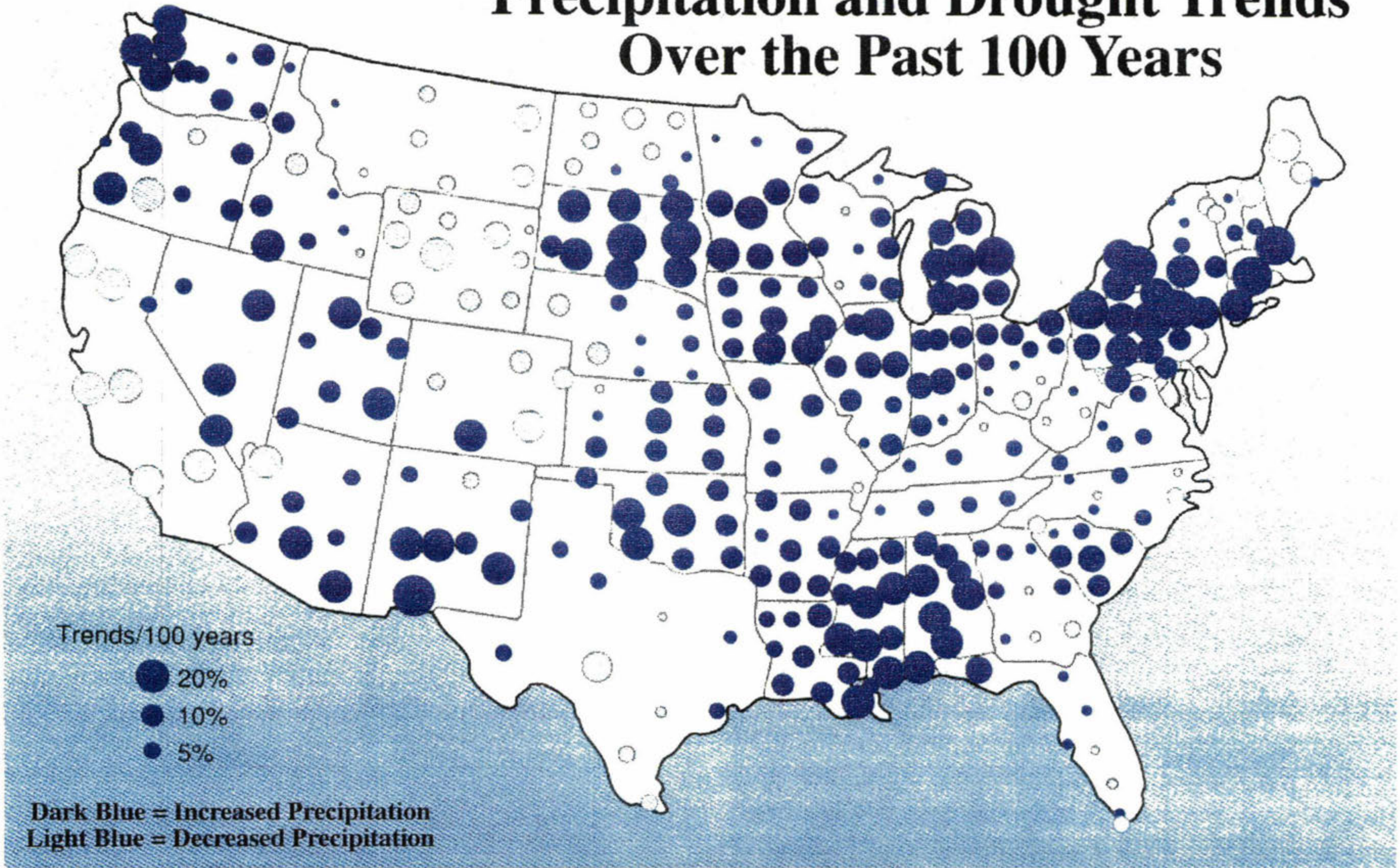
Visuals **Screen 1: Mississippi in non-flood stage** 19
Screen 2: Mississippi during 1993 Flood 20



(15)
U.S. National Precipitation
Deviation from 20th century average
(inches)
6
3
0
-3
-6
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990

16

Precipitation and Drought Trends Over the Past 100 Years



Detailed analysis of these data suggest that "since about 1970 precipitation has tended to remain above the twentieth century mean, averaging about 5% higher than the previous 70 years. Such an increase hints at achange in climate."

Source: Karl et al, Consequences, Vol. 1, No. 1, Spring 1995

17 and 18

New Charts

Not Yet Completed

(19 and 20)

Figure 8 and 9. Our society is already vulnerable to extreme weather events such as floods. These images show the devastating effects of the 1993 Mississippi River flood on St. Louis, Missouri. Climate change is likely to increase the frequency of severe flood events.

Water Resources, Drought, and Climate Change: Don Wilhite, University of Nebraska

Introduction: The combination of increased temperatures and an accelerated water cycle will likely result in altered timing and distribution of precipitation, leading to changes in the distribution of freshwater supplies, increased incidence of drought, and significant impacts on agriculture, ecosystems, and human infrastructure. Extreme climate events during the past few years have demonstrated our continuing and increasing vulnerability to floods and droughts.

- The Northern Plains flooding in April and May of 1997 and cost about $3 billion combined and caused 78 deaths.
- Recent drought conditions in the Southwest and Southern Plains had serious impacts on agriculture, recreation, transportation, forest and range fires, natural ecosystems.
- There were $5 billion in direct drought impacts in Texas alone during 1996.

Climate change will likely result in an increased incidence of drought for many regions of the country, in particular the Midwest, Great Plains, and West. BUT, drought is a national issue because it affects virtually all regions of the country.

Visual: **Screen 1: Recent Droughts Map of US** 21
Screen 2: Drought Effects on Agriculture 22

Drought already results in significant impacts that are region specific because of differences in water management practices and economies. An increase in the incidence of drought will only aggravate existing natural resources management problems. Droughts (and floods) expose the non-sustainability of many of our land use practices and policies. In addition, recent droughts have also exposed our lack of planning for extended periods of water shortage.

- It is critical that we assess current vulnerabilities to droughts and floods and develop contingency plans now which emphasize improved risk management (i.e., vulnerability reduction), and develop the partnerships necessary between levels of governments and with other organizations to improve resource management, especially given possible changes in climate.

- Improving the nation's planning and response capability to extreme climatic events today will be of enormous benefit to our society in adapting to potential future changes in climate.

Southwest: Drought is already a frequent occurrence in the SW, and the shifting precipitation patterns and increased temperatures expected from climate change are likely to increase the SW vulnerability to drought. SW water demand exceeds the supply level, and the demand is growing rapidly. Surface water supplies are insufficient, forcing reliance on groundwater; however, groundwater use exceeds groundwater recharge rates which is leading to the depletion of aquifers and subsidence in many areas.

Great Plains: The Great Plains states are already vulnerable to drought and the further drying expected from climate changes poses a significant risk to the area. Over 90% of the land in the Great Plains is in farms and ranches, and 75% is cultivated. Water sources in the area include rain; surface waters such as rivers, streams, and lakes primarily from snowmelt; and deep aquifers such as the Ogallala aquifer. Agricultural water needs often exceed rainfall, so groundwater use is common. Overdraft of the Ogallala aquifer has already caused the water table to drop, a problem which could become even more severe in the future. The simultaneous drop in aquifer levels, greater run-off from extreme downpours, and shorter duration of snow cover will exacerbate the water problem in the region. The need for irrigation may rise while water supplies are simultaneously diminishing.

To. Rosina Bierbaum 202 456-1025 or Peter Backlund
FROM. DON WILHITE

21

Urgent

OCT- 2-97 THU 14:38

UNIVERSITY OF NEBRASKA–LINCOLN

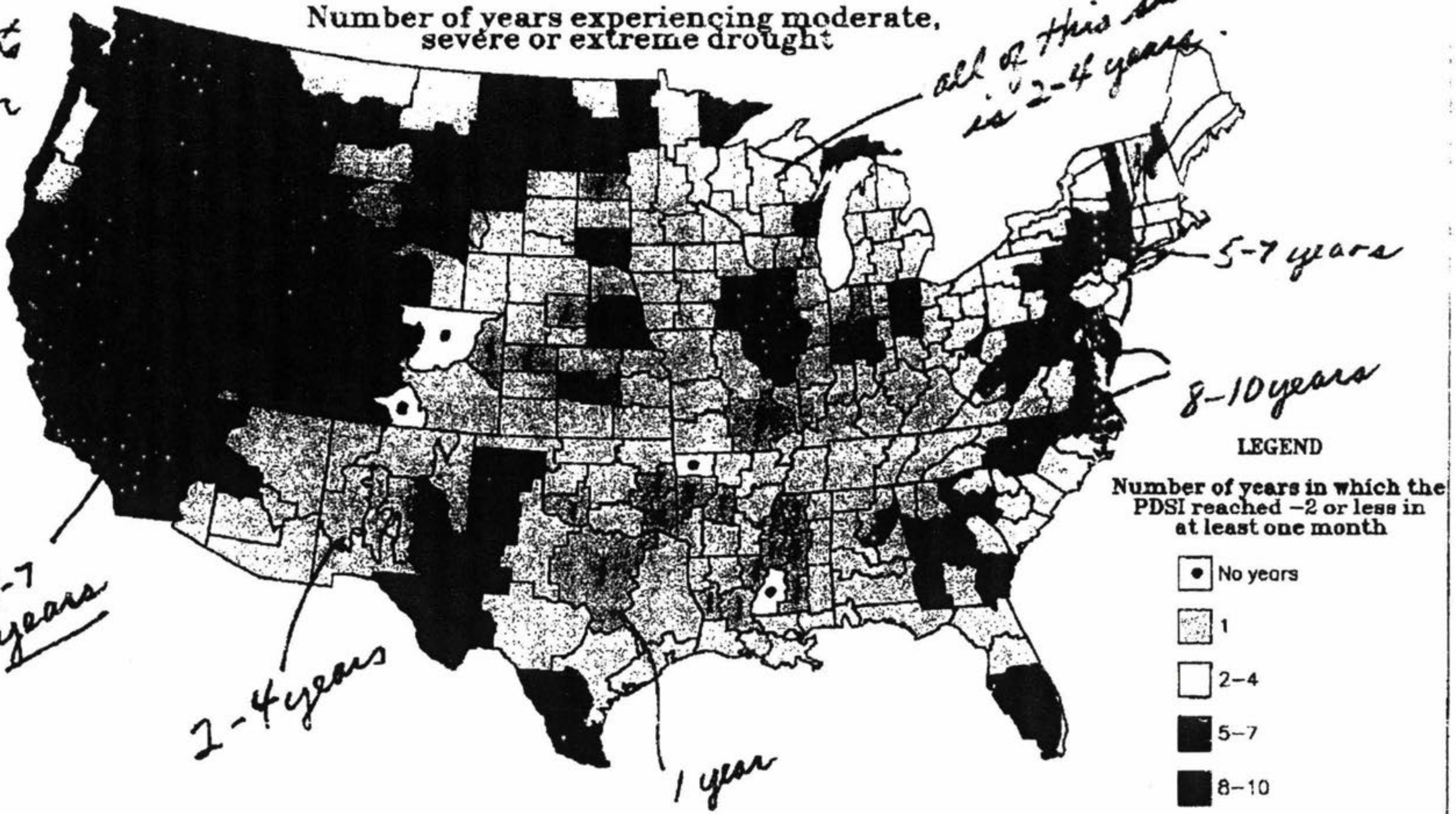
NATIONAL DROUGHT MITIGATION CENTER

Palmer Drought Severity Index

(1987 through 1996)

Number of years experiencing moderate, severe or extreme drought

Many parts of interior west, 8-10 years



SOURCE: NOAA (1990); NCDC (1997)
Albers Equal Area Projection; Map prepared at the National Drought Mitigation Center

Rosina – I have tried to mark this up to help you understand the pattern.

P.01

22

New Chart

Not Yet Completed

Potential Impacts of Climate Change on the United States: Diana Liverman, University of Arizona

Introduction: Climate disruption - warming and changes in the timing, amount, and patterns of precipitation - will have dramatic impacts on human health and well-being and on the natural environment we cherish. The ecosystems upon which we depend for clean air, clean water, food, fiber and recreation will be affected in numerous ways. I'd like to spend a few minutes describing some of the changes that could occur in various regions of the United States.

Plant species migration in New England (Northeast): We all recognize that the distribution of plant species is largely determined by climate – tundra grasses and shrubs in cold, dry places like northern Alaska, tropical and subtropical trees in warm wet places like southern Florida, and so on. As climate zones shift, species distribution will shift. With warming, we expect species to shift poleward and higher in elevation. Let's focus for a moment on the sugar maples of New England – a tree species that is an important part of the colorful pallet that brings millions of tourists to New England in the fall, and that sweetens our breakfasts with maple syrup. Based on historic pollen records, scientists predict that sugar maple trees will migrate north out of New England as the region warms. Sugar maple is not unique. As much as 1/3 of the world's forests species could shift due to climate disruption.

Visuals: ***Screen 1:*** *model estimates of current and future sugar maple distributions (GISS)* 23
Screen 2: *model estimates of current and future sugar maple distributions (GFDL)*

Vulnerability of Coastal Areas in the Southeast: Rapid population growth in the Southeast is already providing significant stresses on fragile wetlands and coastal ecosystems of the region, making the Southeast particularly vulnerable to climate change. Much of the region's population growth is in coastal areas, increasing the risk from frequently occurring extreme weather events. Sea level rise will intensify the coastal areas' vulnerability to storm surges and extreme events. 100 to 1000 feet of Florida beach could be eroded from a 1 foot rise in sea level. The Everglades of South Florida is a vast wetland ecosystem that plays a key role in supplying water for agriculture and cities of South Florida, as well as providing critical habitat for coastal and marine life. The Florida Everglades have already been significantly altered by human activities. Approximately half of the ecosystem has already been lost or severely altered in the past century due to drainage for agriculture and urban development, and nitrogen inputs from agricultural run-off. A third of the Everglades has an elevation of less than 12 inches. A 3-foot sea level rise would inundate the large area of Florida shown in red. Salt-water intrusion will adversely affect delicate ecological communities and degrade the habitat of many plants and animals.

Visuals: ***Screen 1:*** *Florida and/~~or Chesapeake sea-level figures~~* 24
Screen 2: *Coastal wetland photograph* 25

Midwest heat stress: Climate change will impact human health in a variety of ways. Warmer temperatures will increase the risk of mortality from heat stress. For example, in July 1995, 465 deaths in Chicago were attributed to a heat wave with temperatures exceeding 90 °F day and night. Today, such events occur about once every 150 years; in a world with doubled CO2 levels, this type of event may become six times more frequent. Climate change will exacerbate air quality problems, such as smog, and increase levels of airborne pollen and spores that aggravate respiratory disease, asthma, and allergic disorders. Because children and the elderly are the most vulnerable populations, they are likely to suffer disproportionately to both warmer temperatures and poorer air quality.

Visuals: ***Screen 1:*** *Heat stress mortality* 26
Screen 2:

Conclusion: These impacts I have just outlined are only some of the possible implications of climate change. Additionally, the permafrost in Alaska is already melting, and projected to continue to melt; the seasonal water flows in the Pacific Northwest may shift significantly, exacerbating competition between agricultural and hydropower uses, and further threatening the salmon fisheries; and…

23

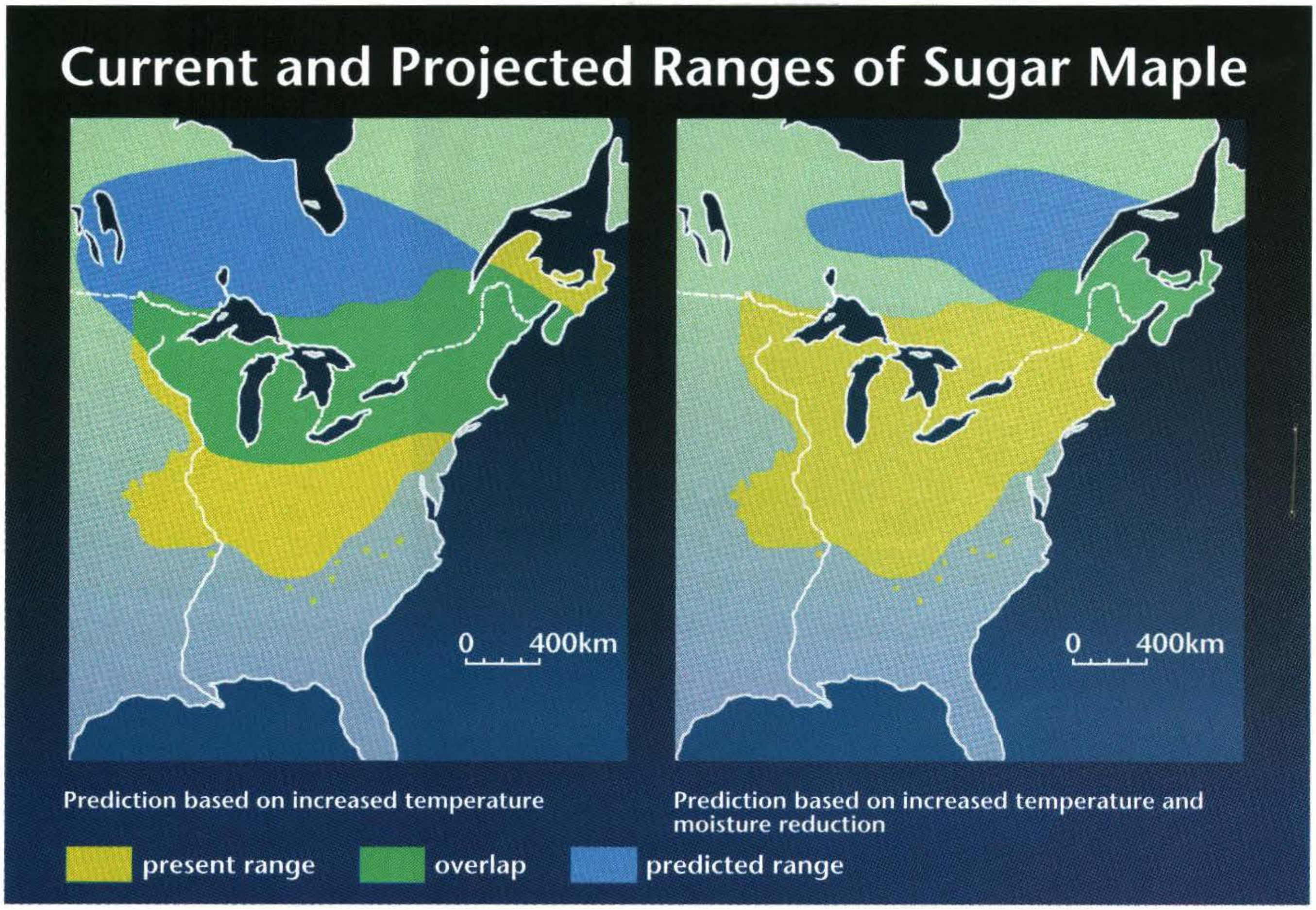
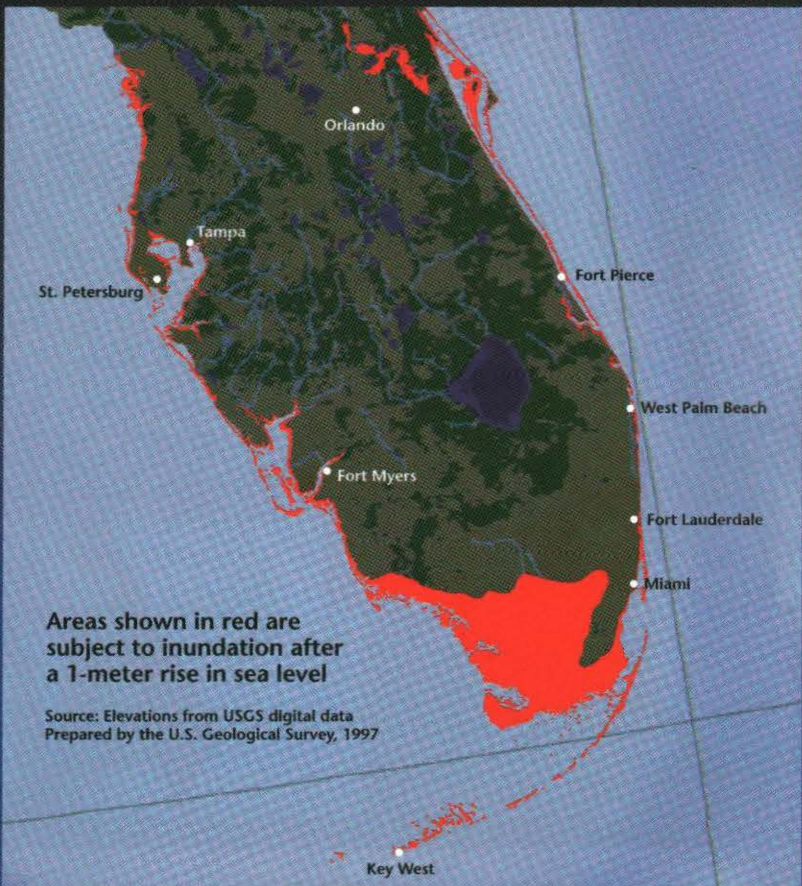


Figure 18. Climatic shifts will force some species to migrate northwards or to higher elevations in order to stay in the appropriate climatic zone. The climatic zone for sugar maple, for example, could shift northwards into Canada. This would compromise the maple syrup industry and the fall foliage colors, both of which make New England famous.

24

South Florida Shoreline Change after a 1-Meter Rise in Sea Level



Areas shown in red are subject to inundation after a 1-meter rise in sea level

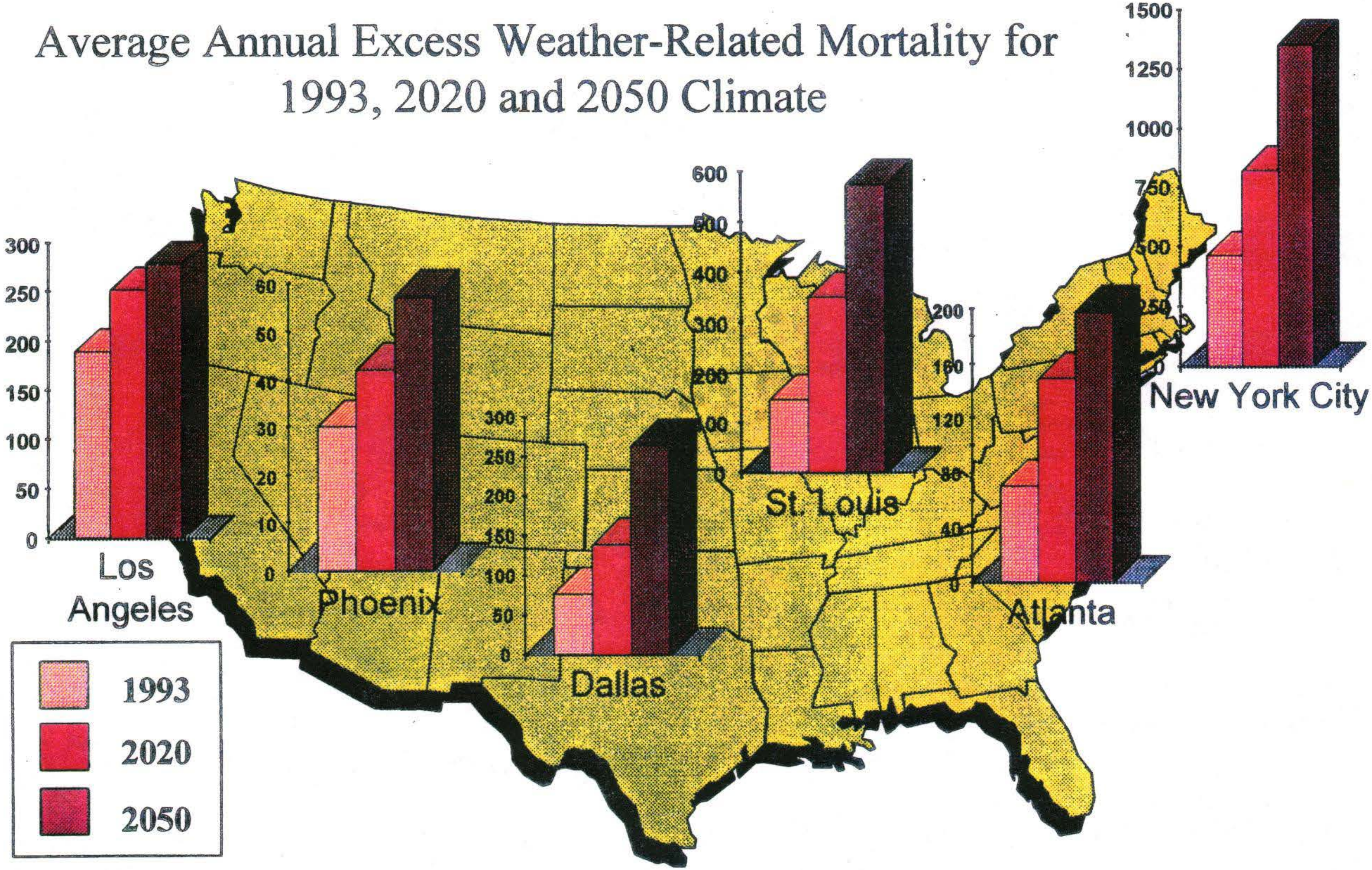
Source: Elevations from USGS digital data
Prepared by the U.S. Geological Survey, 1997

25

Photo not
yet selected

Z 6

Average Annual Excess Weather-Related Mortality for 1993, 2020 and 2050 Climate



Sources: Kalkstein and Green (1997); Chestnut et al.(1995)

GFDL89 Climate Change Scenario

Note: Includes both summer and winter mortality. Assumes full acclimation to changed climate

Why the Skeptics are Wrong: Bob Watson, World Bank, Chair of IPCC

Introduction: How certain is the scientific evidence for global warming? Scientists have gained a great deal of understanding of climate change, drawing in concert from observations, analysis, theory, and quantitative modeling.

- On many points there is nearly uniform scientific agreement, including the existence of the greenhouse effect, the observed increase in greenhouse gases, and the observed warming and precipitation changes over the last 100 years.

- There is a very high level of agreement on the likely future levels of greenhouse gases in the atmosphere given certain economic and population assumptions, and on the conclusion that there is a discernible human influence on the climate. There is also a very high level of agreement that the predicted increases in greenhouse gas concentrations will result in substantial warming over the next 100 years.

There is more uncertainty about the precise rate, amount, and regional-scale distribution of future change. We can make statements about local and regional vulnerability to change with a great deal of confidence, but we cannot yet accurately project exactly what changes will occur in any given spot.

How accurate are the temperature records that show warming? What about the arguments that the surface temperature data is unreliable due to the heat-trapping effect of urban areas? Or that satellite measurements of the temperature of the atmosphere indicate a slight cooling since 1979?

- The IPCC has concluded that since the middle of the last century the global average near surface air temperature has increased about 1 °F. This analysis is based on the instrumental record, which extends back to about 1860, and on tree ring and coral data from which accurate climate records further into the past can be derived. The IPCC is very careful in its treatment of temperature trends, using a multi-year running average that smooths temperatures and therefore does not focus attention on short term abnormalities.

- The observational records indicate that the Earth's surface has warmed over both the northern and southern hemispheres, and the warming is apparent in data taken both on land and at sea. Therefore, the urban "heat island" effect could not be causing all of the observed warming.

- Regarding the differences between the satellite record and the ground-based record, the first point to note is that the short length of the satellite record makes any trend derived from it less robust than longer-term records. Also, since thermometers and satellites measure temperatures at two different places in the atmosphere, it is not surprising that the trends sometimes differ. At higher altitudes, temperatures fluctuate more than at the surface due to natural climate influences like sunlight-reflecting particles from volcanos. Detailed analyses of the satellite records which take into account natural, short-term fluctuations imply warming, just as the ground based measurements have indicated over a longer time period.

Visuals **Screen 1: Temperature record from 1860 until present**
Screen 2: 17 year temperature record from satellites

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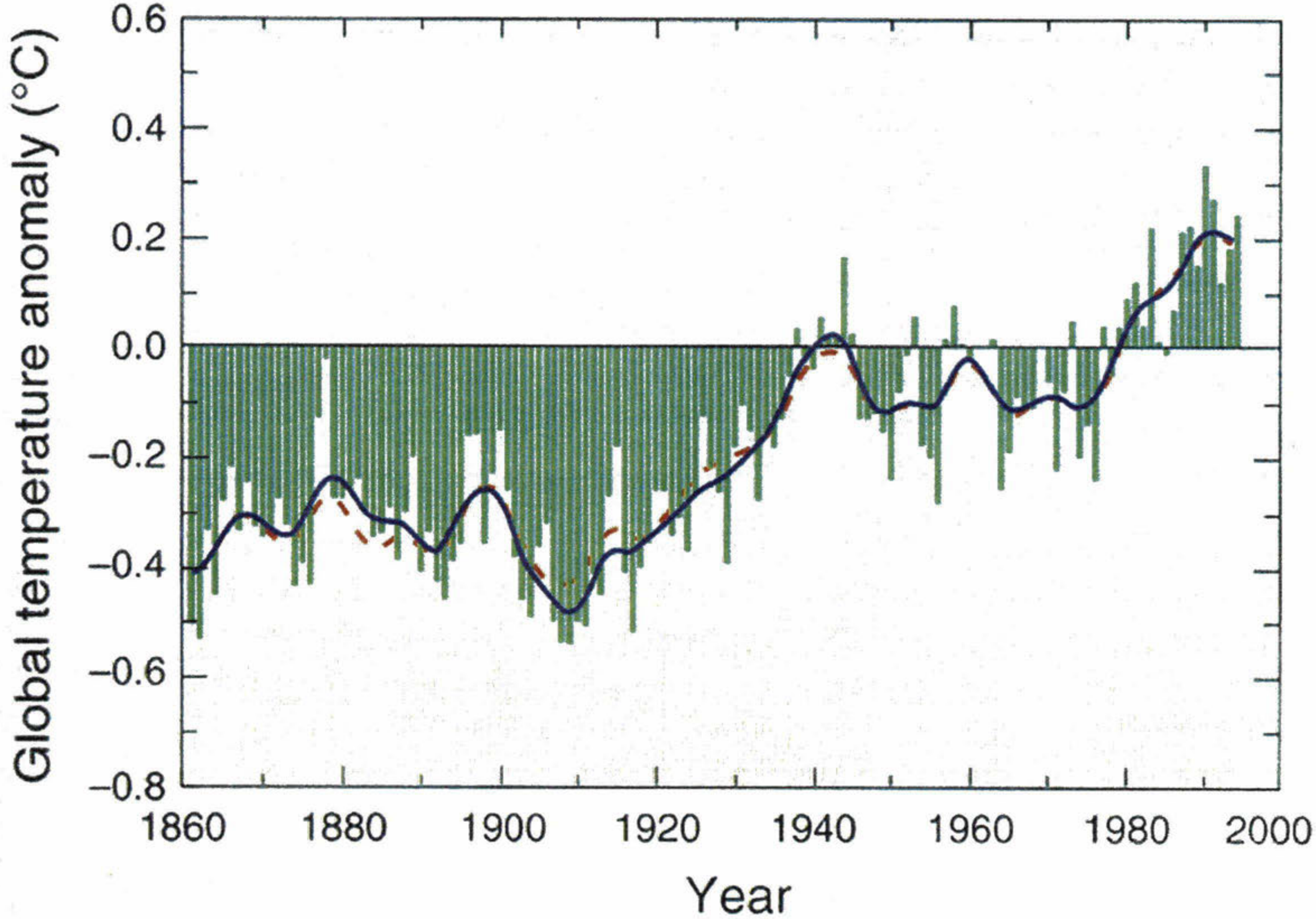
28

Combined Land-Surface Air and Sea Surface Temperatures

Temperatures from 1861 to 1994 relative to 1961 to 1990



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New Chart

Not Yet Completed

What about the people who say that because Carbon dioxide (CO_2) emissions from human activities are a small fraction of natural emissions, human activities cannot be significantly influencing the atmospheric concentrations of greenhouse gases?

- We know that emissions of CO_2 from human activities concentrations have risen dramatically since about 1860. We also know that increases in the atmospheric concentrations of CO_2 closely match the increases in emissions. The measurements are unimpeachable. Furthermore, due to the isotopic "fingerprint" of this CO_2, we know it is from human sources.

Over the last 10,000 years, natural sources and sinks of CO_2 were largely in balance, and the amount of CO_2 in the atmosphere was relatively stable, at around 280 ppm. Over the last century, CO_2 emissions from burning of fossil fuels and land use changes have upset this balance. The oceans and forests can only absorb about half the CO_2 emitted by industry, transportation and other uses of fossil fuels. The rest of this CO_2 builds up in the atmosphere. As a result, CO_2 levels are now 30% above what they were in pre-industrial times.

What about the argument that the intensity of the sun is the real driver of climate change?

- A recent estimate indicates that the warming effect of solar variations since pre-industrial times is only about one-tenth as large as the warming effect of the greenhouse gas buildup.

- The intensity of the sun continuously changes, but there were no direct measurements of these shifts before 1979. The Sun's variations since 1979 have been very small.

- Indirect evidence suggests that the Sun's variations in the past may have been large enough over the course of centuries to affect Earth's climate significantly, but there is simply no reason to think that this influence is more important than that of greenhouse gases over the last several hunderd years..

Aren't the computer models used to project future climate unreliable because they don't reproduce past changes, such as the one-half degree warming over the past century?

- Actually, the new sophisticated computer models do quite well at projecting climate. Using the past century as a test period, these models "project" the past climate quite accurately. When changes in the haze of particles as well as greenhouse gases are taken into account, the models simulate a global temperature trend over the past century which is consistent with the observed warming.

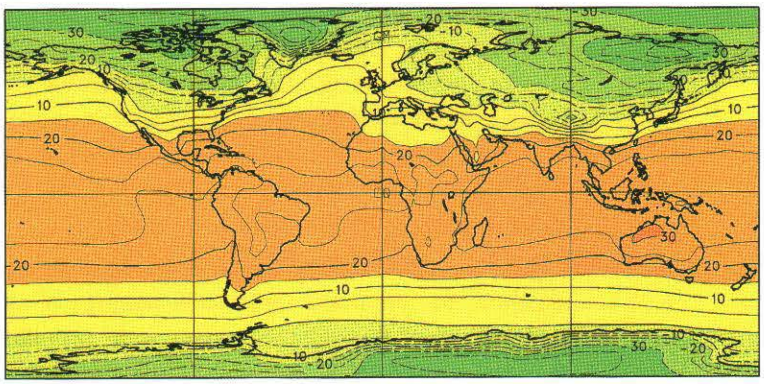
- In addition, there is increasing agreement between the geographical pattern of climate change predicted by the models and the measured pattern of temperature change.

- Models reproduce other key features of global climate, including the magnitude of the temperature variation from winter to summer and aspects of ancient climates inferred from ice cores, pollen and fossil data.

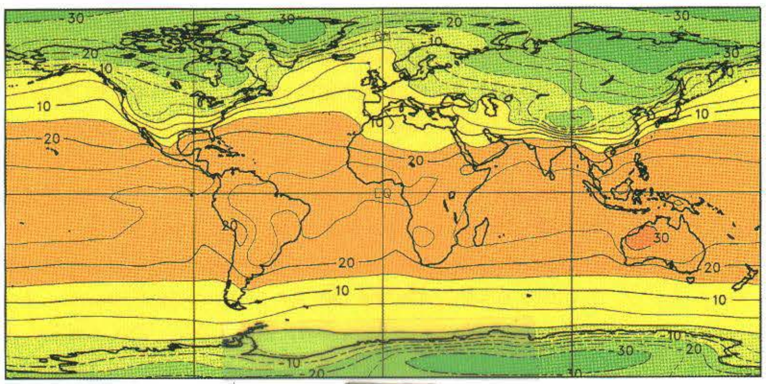
Visuals **Screen 1: Observed Dec - Jan surface air temperature** 29
Screen 2: Modeled Dec - Jan surface air temperature 30

29
and 30

(a) Observed surface air temperature (°C) December-February



(b) Model average surface air temperature



The recent IPCC report reduced the projected global warming by 1/3 compared to earlier work. Given that the predicted increase in temperatures is only 1 to 3.5 C, shouldn't we be less worried now than we were 5 years ago?

- The estimates of warming have been reduced because the computer models of climate have been adjusted to account for the cooling effect of particle haze. The reflection of sunlight by particles partially masks, but does not eliminate, the buildup of the greenhouse effect.

- When developing countries like China move to reduce the emissions of sulfur dioxide which generate these particles (as the U.S., Europe and Japan already have done in order to reduce health effects and acid rain), the cooling effect of the aerosols will no longer offset the greenhouse gas-induced warming.

- The global average temperature has changed by less than a degree Celsius up or down for ten thousand years. So the projected warming is expected to exceed any climate change which has occurred during the history of civilization.

- In addition, even apparently small global average temperature changes will be accompanied by much larger regional climate shifts. For example, a warming which is twice as large as the global average is projected to occur at high northern latitudes.

- Historically, even small global average temperature changes have led to large climate shifts: Earths average temperature increased by only about 5 degrees Celsius between the end of the last ice age and today.

Visuals **Screen 1: Modeled warming from 2XCO2 with aerosol** 31
Screen 2: Modeled warming from 2XCO2 without aerosol 32

WRAP-UP SECTION: John Holdren

The goal of the framework convention on climate change is to stabilize concentrations at a level that prevents dangerous human interference with the climate system.

- The debate over what constitutes a dangerous level is far from resolved, but the relationship of emissions and concentrations is well enough understood to enable projections.

- As I noted earlier, our current course takes to about 710 ppm by 2100, or about double today's level and well on the way to triple pre-industrial levels.

- To stabilize CO2 concentration at 550 ppm -- about a doubling of the pre-industrial level -- worldwide emissions must be slowed in the next 15 years and begin declining steeply during the second quarter of the century.

- The longer we wait to take action, the steeper the future reductions required to achieve stabilization. If we wait too long, some reduction paths become too steep to achieve, and stabilization at low levels is precluded.

Visuals: **Screen 1: Emissions as Usual versus Stabilization Paths** 33
Screen 2: Concentration implications of various emissions levels 34

31
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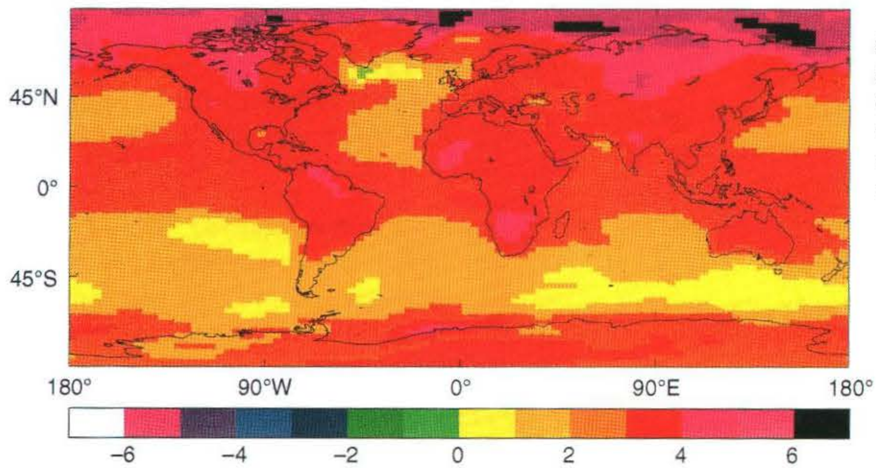


Figure 22: The pattern of surface temperature change projected at the time of CO_2 doubling from a transient coupled model experiment.

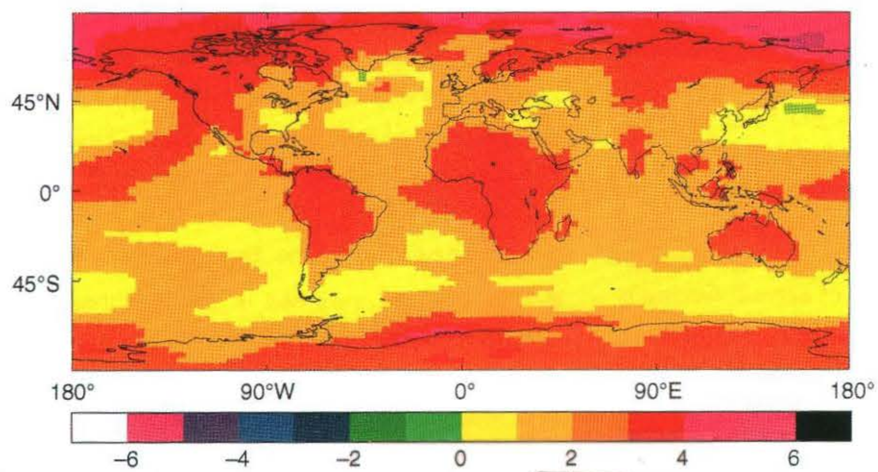
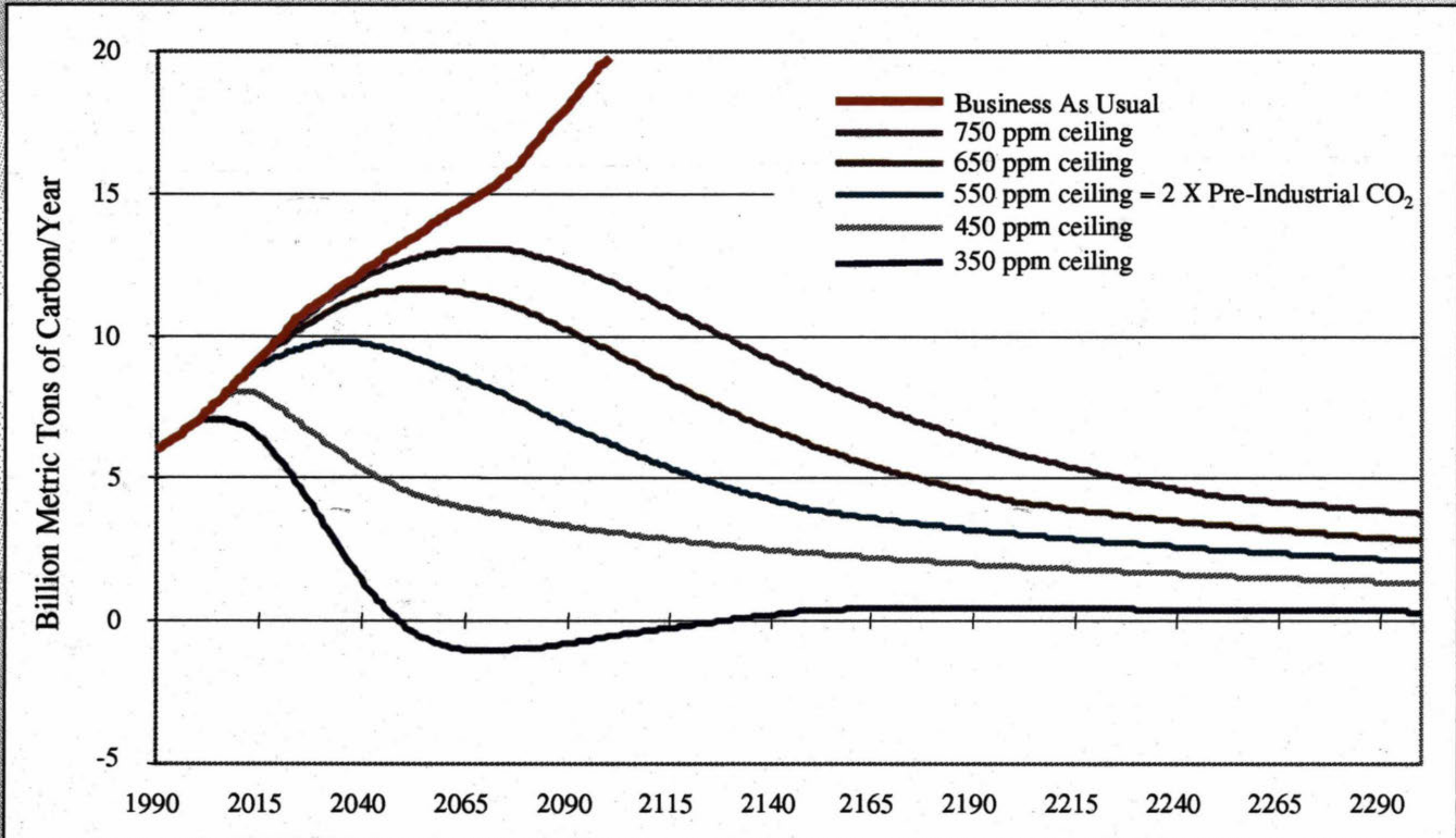


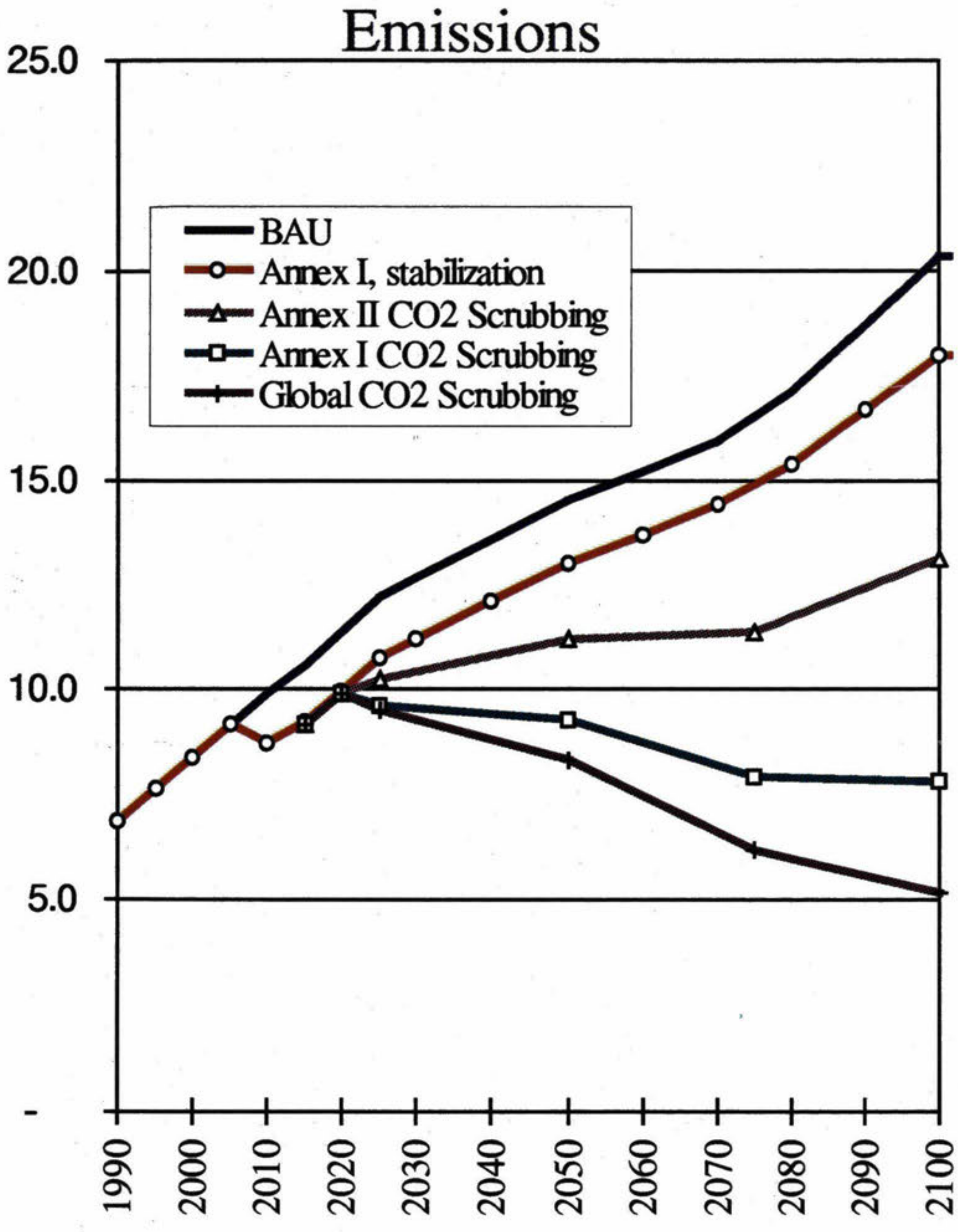
Figure 23: The pattern of surface temperature change projected by a transient coupled model at the time of CO_2 doubling when both CO_2 and aerosol concentration increases are taken into account.

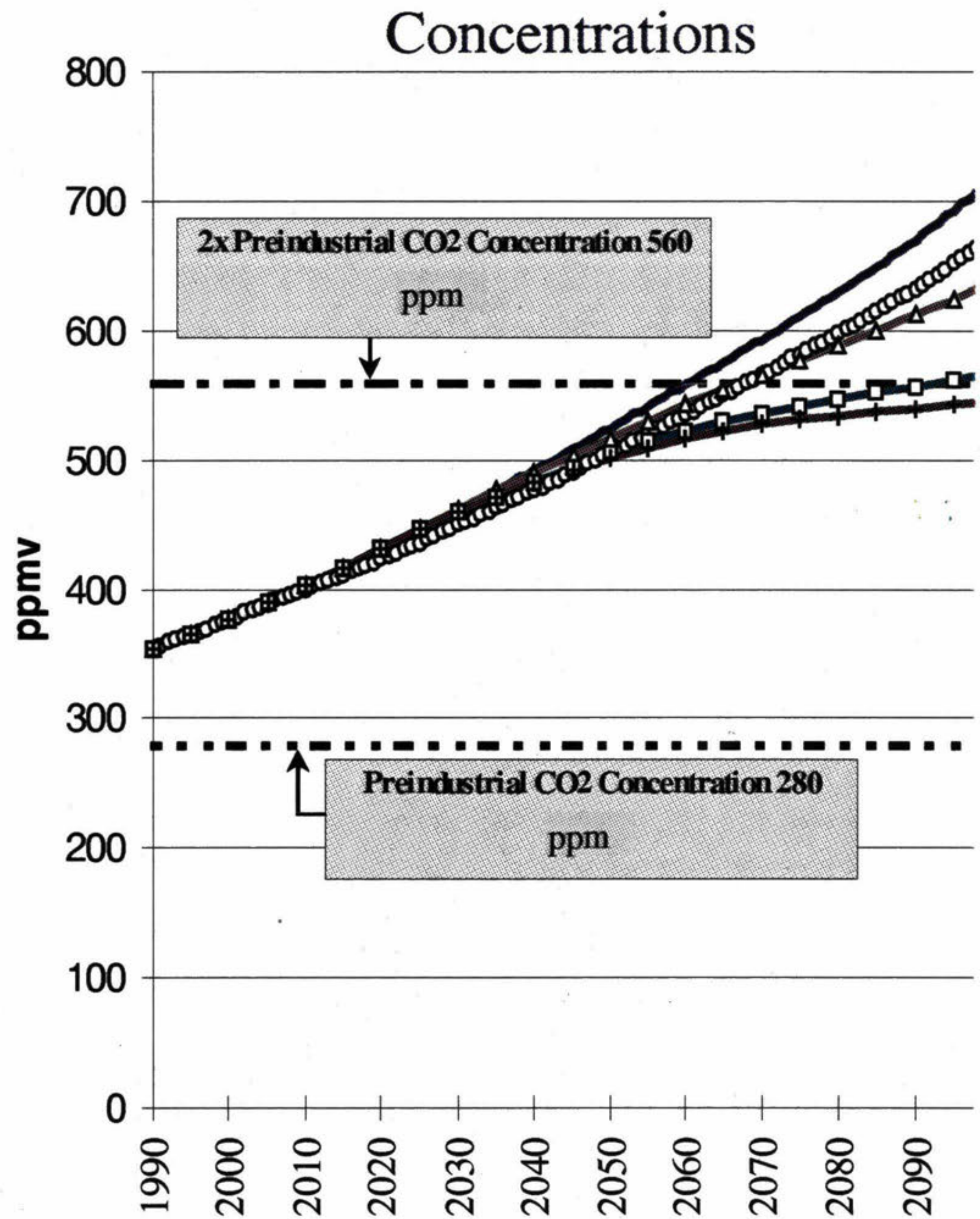
ATMOSPHERIC STABILIZATION EMISSIONS PATHS



(34)

Various Global Emissions and Concentration Paths

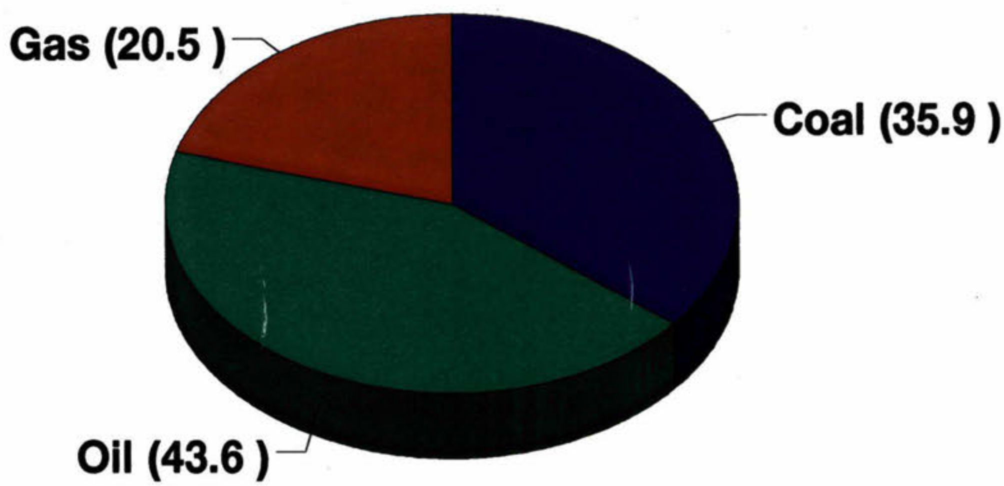




DOE

Examples

U.S. Carbon Emissions



U.S. Carbon Emissions by Sector
(in percent)