AIAM
The World's Leading Automakers®

TECH-96-138
2/27/96

TO: AIAM Technical Committee

FROM: Gregory J. Dana
Vice President and Technical Director

RE: **GLOBAL CLIMATE COALITION (GCC) - Science and Technology Assessment Committee (STAC) Meeting - February 15, 1996 - Summary**

On February 15, 1996, the Science and Technology Assessment Committee (STAC) of the Global Climate Coalition (GCC) met. Enclosed is an agenda, minutes of the last meeting of January 18, 1996, a draft primer on predicting climate change, a draft GCC statement in support of research, an order form for publications, and a copy of a presentation on climate change by EEI. Also enclosed is a brief summary of the meeting. The next meeting is scheduled for April 1996.

GJD:ljf

ASSOCIATION OF INTERNATIONAL AUTOMOBILE MANUFACTURERS, INC.
1001 19TH ST. NORTH ■ SUITE 1200 ■ ARLINGTON, VA 22209 ■ TELEPHONE 703.525.7788 ■ FAX 703.525.8817

February 15, 1996 GCC STAC Meeting
Summary

It was noted that a response to the Jessica Matthews article in the Post was being drafted (contained in the minutes of the January meeting).

A State Department briefing was held just prior to the STAC meeting. A summary of the government position was given:

1. Atmospheric concentrations of greenhouse gases is increasing due to human activity

2. There is a distinct human impact on climate -- estimated range in 0.8 - 3.5 degrees C by 2100.

3. Cost-effective policies and measures exist in both developing and undeveloped countries to reduce greenhouse gases.

4. There is justification for going beyond a no regrets policy -- now doing insurance.

It was noted that this was a significant shift in the Administration's view, that it was being taken from the back office and probably would become an election issue.

Some additional comments from the State briefing: Wirth said that the recent extreme weather has boosted interest in this issue and Eileen Claussen said she didn't see anything coming out of the IPCC process that the U.S. couldn't sign up to.

There was also a report on some discussions with Steve Seidel at CEQ. He is in charge of the update to the Climate Action Plan. He said that there is a lot of analytical work going on, but not all efforts would be released and he wouldn't say who was doing the studies. There is apparently great unhappiness at the White House with studies that have been done -- they have not been favorable on costs or jobs. Expectations are the voluntary efforts have not been working -- oil prices are low, growth is high meaning more emissions. A draft of the plan is expected in about six weeks and then allow six weeks for internal review. The chances for any external review are slim. There is some indication that the government may come out with a call for non-voluntary actions.

Much of the rest of the meeting was taken up discussing the upcoming Intergovernment Panel on Climate Change (IPCC) meeting in Geneva during the last week of February and the first week of March.

From the last meeting of the IPCC in October, a list of 13 items was developed for additional IPCC work. One of those present suggested that some modeling of gases other than CO_2, for their impact on climate change, be done.

The next meeting of the STAC is tentatively scheduled for April 18, 1996.

GLOBAL CLIMATE COALITION
SCIENCE AND TECHNOLOGY ASSESSMENT COMMITTEE
DRAFT AGENDA for the MEETING OF FEBRUARY 15, 1996

The February 15, 1996 meeting of GCC-STAC will be held at the offices of Edison Electric Institute, 701 Pennsylvania Avenue, NW, starting at **Noon**. The draft agenda is as follows:

1. Minutes from January, circulated by Southern Company
2. GCC Report - Holdsworth/Shlaes
3. State Dept. Briefing on Upcoming SBSTA, SBI, and AGBM Meetings - Bernstein, et al.
4. Workshop on NGO inputs at SBSTA Meeting - Bernstein, et al.
5. Follow-up on Science Primer - Bernstein
6. GCC Position Paper on Funding of Climate Research - Gerhi, et al.
7. GCC Follow-up to IPCC Report - Womeldorff
8. Health Issues - Bernstein, et al.
9. Plans for Future Meetings - 3/14 at NRECA, 4/18 at ?
10. Other Business
11. Adjourn (no later than 4:00 p.m.)

GLOBAL CLIMATE COALITION
SCIENCE AND TECHNOLOGY ASSESSMENT COMMITTEE
MEETING MINUTES JANUARY 18,1996

The Global Climate Coalition Science and Technology Assessment Committee met in their regularly scheduled monthly meeting on January 18, 1996 in the offices of Southern Company Services, Inc. An agenda for the meeting was sent to all committee members and is attached to these minutes along with a list of the meeting attendees.

1. The minutes from the November STAC meeting at CMA were approved without comment. The was no December meeting of the committee due to the Christmas holidays. Ned Leonard of Western Fuels Association was introduced to the STAC as one of the GCC's newest members. Western Fuels will be joining at the Board Level.

2. GCC Report - No one from the GCC staff was present at the meeting to provide an update on coalition activities. Connie Holmes, who is the new chairman of the Operating Committee was present as an observer. It was requested that the GCC prepare a generic policy statement on Research. Porter and Lenny will work with representatives from the Economics Committee to develop a draft. The first draft of the document will be developed by the end of the month (January). STAC and Economics Committee members will get a draft prior to their next meeting. Bob Gehri from Southern Company, John Holt from NRECA, and Ned Leonard from Western Fuels Association volunteered to assist in reviewing and finalizing a draft policy statement.

3. Draft Paper on State Of Science - The STAC next took up the draft paper on the State Of The Science paper that has been developed by Lenny Bernstein. Lenny indicated that so far general comments had been constructive on the first portion of the paper. Most suggestions had been to drop the "contrarian" part. This idea was accepted and that portion of the paper will be dropped. The ideas brought out in the "contrarian" section may be dealt with in a future paper.

   Most of the remainder of the meeting was spent conducting a paragraph by paragraph review and of the document by STAC members.

4. Communication Committee Request - David Banks requested help in identifying a medical person or persons that could assist the GCC with the health effects issue. So far, the candidates offered by member companies did not have appropriate credentials to be a spokesman for the issue. It was felt that someone with a medical degree and some reputation (i.e. C. Everett Koop). All materials currently being used by the Communications Committee need to be updated in light of the IPCC SAR and the developments in the AGBM process.

5. Articles recently published in the Washington Post, The New York Times, and Newsweek concerning recent weather events and global warming were distributed to those attending. Charles Krauthammer (sp?) is preparing a response article to the Jessica Matthew's article.

6. Porter Womeldorf and Lenny Bernstein gave a report on the recent IPCC WGI Plenary Session in Madrid, Spain and the IPCC Synthesis Report Meeting held in Rome, Italy.

7. E. Bruce Harrison, the consultant to the GCC Communications Committee, requested that the STAC approve a paper by Hugh Ellsaesser et. al. discussing detection and attribution issue. The paper is entitled Comment on Santer et al., "Towards the Detection and Attribution of an Anthropogenic Effect on Climate," PCMDI Report No. 21, January 1995. Comments were requested to be sent to Lenny Bernstein by February 1. Chuck Hakkarinen cautioned that use of the article may be premature since neither the article by Ellsaesser or the article that it is responding to have been published in peer-reviewed literature at this time.

8. The next meeting of the GCC STAC will be held at EEI on February 15th from 11am to 4pm. The address is 701 Penn. Ave. N.W. and the meeting will be held in the Ben Franklin Room on the 4th floor.

Attendees List GCC STAC Mtg. 1-18-96

Name	Company	Phone / Fax
Robert Gehri	Southern Company	205/870-6220 + 877-7938
NED LEONARD	WESTERN FUELS ASSN	703/907-6163 FX 6161
HOWARD FELDMAN ✓	API	202 682 8340 fx 8270
ERIC KUHN ✓	CINERGY CORP.	513/287-4061 / 3499
JOHN HOLT	NRECA	703 907 5805 / 5517
CHUCK SHARP	AAMA	202 326-5542 / 5567
CHUCK HAKKARINEN	EPRI	415 855 2592 / 106[illegible]
Jerrel Smith	Union Electric	415-554-2106 / 4830
Eric Reiner ✓	3M for CMA	612 778-5079 / 6176
Connie Holmes	NMA	202-463-2654 / 202-833-963[illegible]
P. J. WOMELDORFF	IL POWER CO	217/422-9174 T/F auto dial[illegible]
Lenny Bernstein ✓	Mobil	
Roy Hamme	Duke Power	704/875-5935 / 5493
Bob McFadden	AAMA	202/326-5523 / 5528
John Kinsman	EEI	202/508-5711 / 5150
DAVID BANKS	API	202/682-8119 / 8115

Jessica Mathews

Is Global Warming the Problem?

Don't laugh. Strange things happen when we alter the climate.

BY JAMES THRESHER—THE WASHINGTON POST

I've taken a lot of ribbing from friends and neighbors this blizzard week. "Global warming, huh?" has been the general jest.

An affirmative answer tends to bring derisive laughter or at best a lifted eyebrow. Nevertheless, it's true. Hard as it may be to believe, blizzards like this one are part of what the experts tell us to expect of a warming climate.

On the supposition that this is one of those rare moments when people are actually interested in the weather, here's why.

A warming climate doesn't mean there won't be winters. It does mean more heat and therefore more energy in the atmosphere. Warmer air can hold more moisture. (Most skiers can remember being told that "it's too cold to snow.") Warmer temperatures also mean that moisture on the ground evaporates more rapidly. Together, these phenomena mean that more water cycles between earth and sky, evaporating more quickly and coming back down as rain or snow in greater volume. This more vigorous global hydrological cycle is one of the most certain characteristics of a greenhouse-altered climate.

More energy and moisture in the atmosphere also raises the probability of more intense weather events, particularly of more extreme precipitation. This is one of the predicted characteristics of greenhouse warming that has already been documented for the United States. Based on a century-long record, our weather has become more extreme in the past 15 years, with an index 40 percent higher than natural fluctuation should produce. The greatest single change has been in the proportion of extremely heavy precipitation—two inches of rain or more in 24 hours. In the past year Midwesterners coped with the second "100-year flood" in two years, and Texans had flooding with hailstones the size of baseballs.

Capping a two-year review by several thousand scientists, 120 governments agreed last month that "the balance of evidence . . . suggests a discernible human influence on global climate."

In other words, greenhouse warming is underway. There remains considerable uncertainty about how much and how fast climate will change, but even in the lowest case the average rate of warming is expected to be "greater than any seen in the last 10,000 years," a major change in climatological terms.

No single weather event tells you anything about climate, and no single one can be linked to greenhouse warming. Natural variability can produce a blizzard or freak flood at any time. The key point is that events like these are what we should expect—not in the future but right now. We are already living in a changing climate that holds more potential for events like White Monday.

The old saw, "Everybody talks about the weather, but nobody does anything about it," no longer holds. We are all doing something about it with carbon dioxide, methane and other greenhouse gas emissions every day.

That means keep the shovels handy, but don't expect predictability. Greenhouse effects can be gauged most confidently as global averages. A few changes seem pretty certain on the continental scale, but very little can be said about local climate. Also—this only sounds like an oxymoron—expect surprises. Climate is what is known as a non-linear system. Even relatively simple non-linear systems are unpredictable. Infinitesimal change in one factor can produce enormous changes in outcomes. When subjected to large nudges, such as those caused by greenhouse gas emissions, such systems are, in the words of the international review panel, "especially subject to unexpected behavior."

In other words, we can expect a class of predictable surprises—more weather extremes like this blizzard—and unpredictable surprise as well.

As the debate begins in earnest over what to do about greenhouse warming, the storm is a useful reminder of how vulnerable we still are to the weather. With air-conditioned cars, irrigated agriculture and artificial snow on the ski slopes, it's easy to think that we've left behind the era of dependence on Mother Nature. It ain't so.

From losses in air and ground transportation, food and retail sales, chaos in school schedules and lost worker productivity—not to mention cleanup costs—this will be a multibillion-dollar storm. The New York area alone is already estimating costs in excess of $1 billion. Federal disaster funds have been necessary to keep road and ambulance crews working. This comes on top of last year's killing heat waves, the $12 billion flood of '93, and the $17 billion cost of Hurricanes Andrew and Iniki in '92, to mention just a few among recent (perhaps not wholly) natural disasters.

Adaptation to changing climate is perfectly possible, but it's a tricky business. Cities could begin to budget for more snowplows, but with no certainty that they'll be needed. With plenty of certain needs, that becomes a very tough call. Other adjustments will involve juggling much larger costs with the unknowns. Many could prove to be agonizingly difficult public choices.

As you shovel, think of the blizzard of '96 as a glimpse of a part of the likely greenhouse future.

The writer is a senior fellow at the Council on Foreign Relations.

THE NEW YORK TIMES, SUNDAY, JANUARY 14, 1996

Ideas & Trends

Blame Global Warming for the Blizzard

By WILLIAM K. STEVENS

IT seems a paradox at first glance: How could a record snowstorm have covered much of the northeastern United States last week when the climate of the earth is warming?

Just four days after scientists announced on Jan. 3 that the average surface temperature of the globe had crept to a recorded high of nearly 60 degrees in 1995, the Blizzard of 1996 dropped more than 20 inches of snow on Central Park, the third deepest snowfall ever measured there. More than two feet fell on other parts of the Northeast corridor.

But not only are blizzards and global warming compatible, some experts cite evidence suggesting that climatic changes associated with global warming are actually creating more severe snowstorms.

The apparent planetary warming is unlikely to nullify the seasons, including winter, although some climatologists say severe cold spells should eventually become less frequent if the warming continues as predicted.

Frigid masses of Arctic air still rule the polar winter, and a southward bulge of this polar chill was a crucial element in producing the blizzard. Another such bulge has been responsible for the bitter weather frustrating American troops in Bosnia. Seasonal movements of air like these easily overwhelm the relatively small amount of global warming observed so far.

Current Events

Moreover, other parts of the globe have been unusually warm despite the cold start to winter here and in Central Europe.

While the blizzard paralyzed New York, Southern California enjoyed record warmth. The summertime temperature in Argentina at a latitude roughly comparable to that of Washington, D.C., soared to 110 degrees a few days ago.

And even where it has been cold, global warming may be contributing to heavier snowfalls and greater extremes of precipitation generally.

A warming atmosphere causes more evaporation of water from the ocean, which means more rain, snow or sleet. The conversion of more water from vapor to precipitation also releases more energy into the atmosphere, making storms more powerful. In cases where atmospheric circulation conspires to keep rain away from a given area, as happens from time to time, a warming climate is expected to produce hotter heat waves and more severe droughts.

Extremes of this kind are becoming more frequent, say researchers at the National Climatic Data Center in Asheville, N.C.

Last year, the researchers analyzed temperature and precipitation records for the 20th century and found that from 1980 through 1994, the incidence of extreme one-day precipitation, over-all precipitation, above-normal temperatures and drought had risen in many areas of the country.

By comparing this pattern with the pattern of climate change that computer simulations indicate should result from an increase in heat-trapping "greenhouse" gases like carbon dioxide, the analysts concluded that there is a 90 to 95 percent chance that the increase in extremes was caused by the increase in greenhouse gases.

An authoritative group of scientists advising the United Nations recently concluded for the first time that the greenhouse gases — produced by the burning of coal, petroleum and wood — are probably responsible for at least part of the observed warming.

The average surface temperature of the earth has risen by about 1 degree Fahrenheit in the last century. The scientists forecast a rise of another 3.6 degrees over the next century if emissions of the gases are not reduced, the most rapid global temperature change in the last 10,000 years, with further warming after 2100.

That may not sound like a lot of warming, but the average global temperature is only 5 to 9 degrees higher now, depending on varying calculations, than it was in the depths of the last ice age.

If the scientists are right, extreme weather will be a hallmark of the changing climate, and in fact may be the most common way in which people experience global warming.

One particularly revealing index of extremity is the amount of precipitation in a 24-hour period. Extreme rainstorms, snowstorms, ice and sleet storms, have become more frequent in the United States, and several locations reported record 24-hour snowfalls last week.

The Blizzard of 1996 does indeed qualify as one type of extreme weather to be expected in a warmer climate.

"It's another statistic that adds to the record" of extreme precipitation, said Thomas R. Karl, the leader of the Asheville research team that is studying the phenomenon. "It's rather interesting. We seem to be getting these storms of the century every couple of years." Mr. Karl has not been known as a doom-sayer on the question of global warming.

Paradoxically, an increase in the temperature of the Earth may mean more severe snowstorms and droughts as well as hotter heat waves.

As Northeasterners showed last week, people can adapt to extreme weather, but at costs both monetary and human.

The blizzard may have cost the New York region a billion dollars and it caused many deaths. Floods resulting from extreme rains, like the historic ones in the Mississippi basin in 1993, take a toll both in dollars and disaster. Extreme heat waves like last summer's in Chicago, which Mr. Karl says may have been worsened by global warming, impose extreme and often lethal hardships on the old and weak. Developing countries, many of which have fewer resources to cope with a changing climate, are generally regarded as most vulnerable.

For all the tantalizing signs and signals, it remains uncertain as to whether human activity is changing the climate a little or a lot, and if a lot, how drastic the change will ultimately be.

Long-range climate forecasting is no more precise than short-range weather forecasting, both based on an imperfect understanding of the turbulent atmosphere and on equally imperfect analytical tools like computer simulations of the atmosphere's workings.

Sometimes, the task of predicting the weather a season ahead is made easier.

For instance, forecasters know that the quasi-periodic appearance of El Niño, the vast pool of warm water in the equatorial Pacific, increases the probability of certain atmospheric events. They can predict that when El Niño appears, the northern jet stream, the high-altitude river of air that girdles the northern hemisphere, will shift to a course that blocks any invasions of polar air in the northeastern United States.

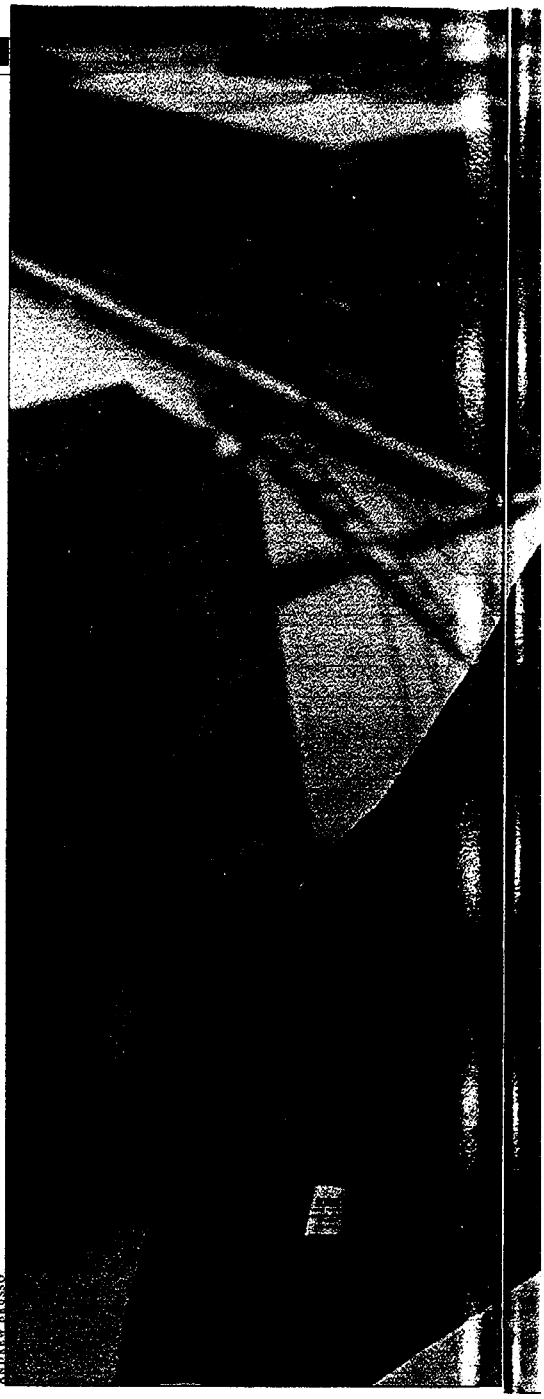
That was the case a year ago. Forecasters at the Climate Analysis Center of the National Weather Service at Camp Springs, Md., predicted a mild winter for the Northeast last year. They were right; on Jan. 13, 1995, for instance, the temperature reached 61 degrees in Central Park.

This year, El Niño has disappeared. The Weather Service nonetheless predicted a warm winter again based on previous weather patterns, but that forecast has turned out to be wrong so far. The winter is young enough that the forecast could still be right in the end. If not, it will be testimony to the hazards of trying to gauge the behavior of the atmosphere far in advance.

"It comes with the territory, and we accept that," said Ed O'Lenic, who heads the Climate Analysis Center's forecast operation.

What you see as storms, the world's weatherman sees as evidence of global warming, further proof that ...

He's Not Full of Hot Air



ANDREW BRUSSO

BY SHARON BEGLEY

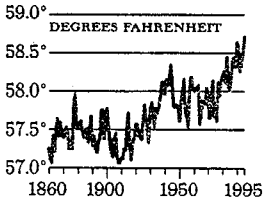
SEVEN FLOORS BELOW, THE streets of Manhattan's Morningside Heights have taken on the look of a maze, with walls of white channeling the scurrying pedestrians into precise paths. It snowed last night, and for a while it showed no inclination to stop. Ever. Rulers won't do; to measure the accumulation, yardsticks are in order. So if this seems like an odd moment to turn one's thoughts to the *warming* of the world's climate, well, James E. Hansen begs to differ. "No, this is the perfect time!" the director of NASA's Goddard Institute for Space Studies in New York says in his crammed office. "As you get more global warming, you should see an increase in the extremes of the hydrologic cycle—droughts and floods and heavy precipitation."

Hansen, 54, is back where he's most comfortable: out on a climatological limb. It hasn't been sawed off from under him yet. In 1981 this weatherman to the world bucked the scientific consensus that the planet was getting cooler. He argued that, to the contrary, the globe had warmed 1 degree Fahrenheit in the last century—because industrial gases were trapping heat in the atmosphere. He was right, it turns out, and "that was the first thing that got us in trouble," he says with a faint smile. In the spring of 1990 he bet a colleague that at least one year from 1990 to 1992 would be the warmest on record. When 1990 topped the charts, Hansen pocketed $100. Then he nailed his prediction that the 1991 eruption of Mount Pinatubo in the Philippines would put a lid on the warming trend until the 20 megatons of heat-reflecting volcanic dust had settled. And four days after 1995 was history, Hansen announced that it had been the hottest year ever, an average 59.7 degrees. It wasn't a quirk: Pinatubo had lowered the average global temperature so significantly that "it would be very unlikely" for chance alone to push the mercury to a new record.

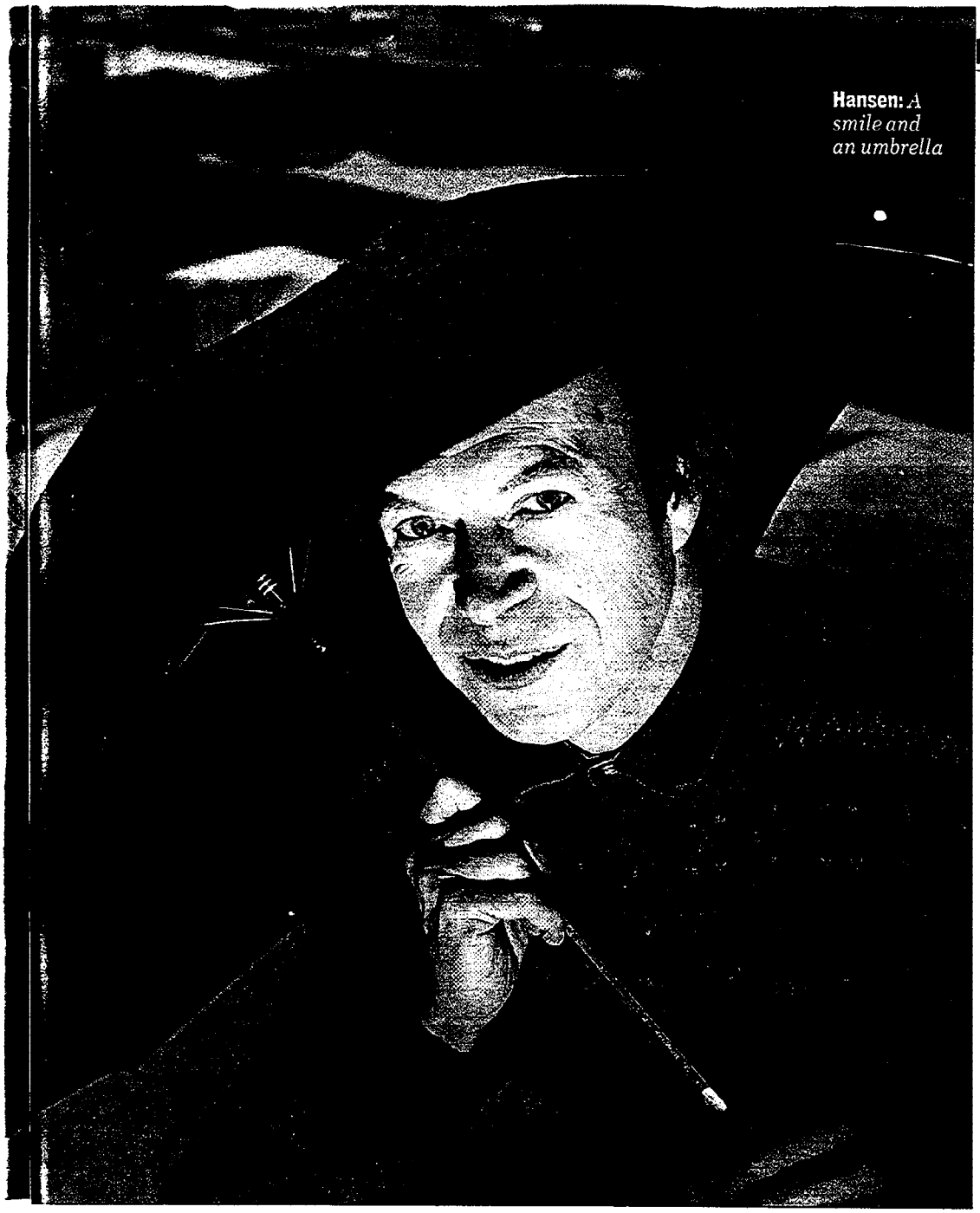
It's even less likely that chance alone could explain weather that, in 1995, gave new meaning to "capricious." In Antarctica, a 'berg the size of Rhode Island broke off, and flowers bloomed on the ice shelves (map, page 26). Seas warmed off southern California, decimating populations of zooplankton that sustain fish; Northern Europe bailed out from under spring floods. Eleven hurricanes—the most since 1933—pummeled the Caribbean. More than 800 people died in the Midwest's summer heat wave, and London had its hottest, driest summer in 200 years. Northeast Brazil suffered its worst drought of the century and now its south is underwater: Rio has already had three times as much rain in eight days this month as it usually gets in all of January. Siberia was a full 5 degrees hotter than normal last year. Alaska has had almost no snow

Getting Warmer

The average surface temperature of the earth has risen more than 1.5 degrees in the last 135 years.



SOURCE: CLIMATIC RESEARCH UNIT, UNIVERSITY OF EAST ANGLIA



Hansen: *A smile and an umbrella*

this season—but Memphis, Tenn., would love to ship it some. "The more rapidly we force changes in the [climate] system," says Stephen Schneider of Stanford University, "the more likely it is to exhibit inscrutable behavior."

"Inscrutability" to a scientist is like a vacuum to nature: theories rush in at the speed of sound. The theory in this case is that the world is caught in the grip of a "greenhouse effect." Gases such as carbon dioxide, released when fossil fuels like coal and oil burn, trap infrared (heat) radiation in the atmosphere much as panes of greenhouse glass do. Since the atmosphere's load of these gases keeps rising, the world will almost certainly get warmer. The Intergovernmental Panel on Climate Change, sponsored by the United Nations, last month forecast a rise of 1.8 to 6.3 degrees by 2100. Since the IPCC can hardly agree on what to order for lunch, that unanimous prediction was a milestone. Even representatives from Kuwait and China were on board: the two countries resist the idea that the world is warming because greenhouse panic could bring restrictions on oil and coal.

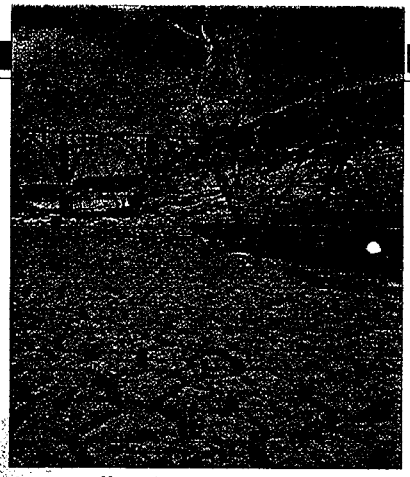
But consensus ends right about there. Not even researchers who agree that the world is warming, and will keep warming, agree on what happens next. On the one hand, Panglossians foresee milder winters and bumper crops from Kansas to Siberia. Despite the recent weather, they expect fewer severe storms in the future: temperature differences between the poles and the equator will even out, and the fury of storms will therefore diminish. Cassandras, on the other hand, warn that in a warmer world agricultural zones will shift, causing a mismatch between climate, soil and rainfall that could empty many of the world's breadbaskets. Sea levels will rise between 6 and 38 inches, obliterating islands, robbing coastal New Jersey and Louisiana of congressional districts and forcing Kevin Costner to rebuild his ark. Up to two thirds of the world's forests could turn to grasslands. The Mideast and northern Africa can expect widespread droughts. A balmier North Pole could alter ocean currents that now warm Western Europe; there will always be an England, but it might not be able to cultivate buttercups.

Meaner storms: It's too soon to tell which side knows what it's talking about. But one alarming prediction seems to be coming true: the expectation that, in a warmer world, extremes of wet and dry will intensify. As Earth's surface warms, more moisture evaporates. Over arid regions, where there's little to evaporate, turning up the thermostat would exacerbate droughts. Rainfall would thus increase over moist areas, like the coasts, and be rarer in the interiors of continents. "The odds of getting drought years will increase markedly," says Jerry Mahlman, director of the Geophysical Fluid Dynamics Laboratory, part of the National Oceanic and Atmospheric Administration (NOAA). Hurricanes, too, should get more intense. "The warmer the ocean gets, the meaner the tropical storm," says A. E. (Sandy) MacDonald of NOAA's lab in Boulder, Colo.

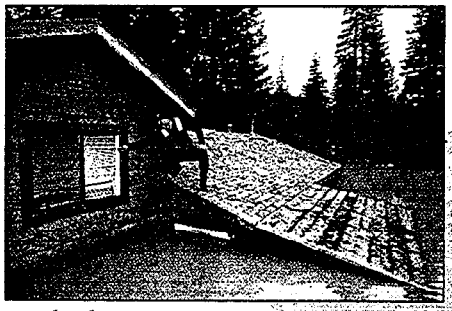
Last week's blizzard can't be blamed on the warming world. No storm or drought or heat wave ever can be so neatly diagnosed. "You can't connect a given weather event on a particular day in a particular place with long-term climate change," says physicist Michael Oppenheimer of the Environmental Defense Fund. The snows of yesteryear prove that. The record Northeast blizzards of 1888 and 1947, after all, hit when the only greenhouse effect anyone cared about was the one that forces lilies to bloom for Easter. Extreme weather is connected to global warming more subtly. "All that long-term climate change can do is

Going to Extremes

The weather is always capricious, but last year gave new meaning to the term. Floods, hurricanes, droughts—the only plague missing was frogs. The pattern of extremes fit scientists' forecasts of what a warmer world would be like.



Spain suffers through a 5-year drought



Floodwaters cover Sonoma County, Calif.

Northeast and Midwest: July's heat wave killed more than 800 people, including hundreds in Chicago alone.

British Isles: Severe summer heat wave and drought. London had its hottest summer since 1659.

Central and Northern Europe: Above-normal rainfall early last year caused flooding in France and the Netherlands.

California: Heavy rains in March led to flooding throughout the state, causing 15 deaths and $2 billion in damage.

Midwest: 1,011 tornadoes were reported, the second most active season on record.

East Coast: Hot and dry summer; then the blizzard of '96 buries the Northeast.

Southwest Europe, Northwest Africa: Protracted drought through first six months of '95.

Austria: Record highs now being set. World Cup ski events canceled for lack of snow.

Caribbean: Eight tropical storms and 11 hurricanes made this the worst season since 1933.

Mexico: Northern parts of the country are experiencing the coldest weather in 25 years. On New Year's Day, Mexico City saw its first real snowfall in two decades.

West Africa: Prolonged drought.

Ghana: July saw its heaviest rainfall in 30 years, with 20 deaths from flooding.

Northeast Brazil: Suffered its worst drought of the century last year, with only 40% of normal rainfall.

Rio de Janeiro: The March rains have come early this year, already bringing more rainfall than January's monthly average.

South Africa: The '95 wet season was late, then caused widespread flooding.

Hurricane Luis hits the Caribbean

Argentina: The plains region experienced its worst drought in history. The Patagonia forest is having one of its most active fire seasons in memory.

Antarctica: A 48-by-22-mile piece of the Larsen Ice Shelf fell off.

A twister storms through the Midwestern U.S.

Hurricane/tornado/typhoon · Drought · Heavy rain/snow · Heat wave

CLOCKWISE FROM TOP LEFT: J. PATRICK FORDEN—SYGMA, DESPOTOVIC—SYGMA, SANKEI SHIMBUN—AP, AFP, JON JONES—SYGMA, RICH SAAL—SPRINGFIELD STATE JOURNAL-REGISTER-SIPA, AMANTA—SIPA

Blizzards sweep through northern Japan last week

Siberia: A five-degree increase in average temperature for '95 was the largest in the world.

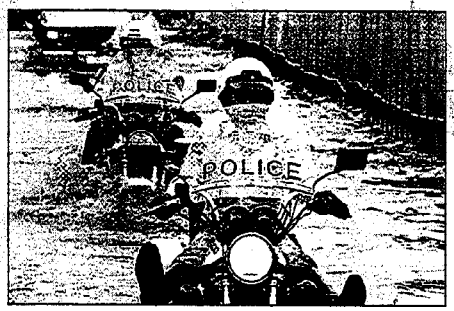
Russia: Moscow's May 31 temperature hit 91° F, breaking the previous record.

NE China, Korean Peninsula: Summer rain and flooding led to famine in some regions.

Japan: With unprecedented snowfall in the north, the city of Sapporo last week asked for military assistance in removing snow.

India, Bangladesh and Nepal: June monsoons caused massive flooding, stranding nearly 2 million people and killing more than 100.

Philippines: Typhoon Angela, the area's most powerful storm since 1984, hit in November, killing more than 600 people.



Heavy rains drench the Philippines

Australia: The weather has been wet in the west, with record-high levels of rainfall. In the east, Sydney had its first rainless August ever recorded.

Fires in drought-ridden New South Wales

NEWSWEEK GRAPHIC BY DIXON ROHR
RESEARCH BY BRAD STONE AND BRUCE SHENITZ
SOURCE: CLIMATE PREDICTION CENTER/NOAA

affect the probabilities," Hansen explains. Instead of equal chances that any one storm will be heavier or lighter than normal, or any one day hotter or colder than normal, the climate dice are now loaded. The greenhouse effect, says Hansen, "has changed the odds" on extreme weather.

Whatever its proximate cause, the blizzard of '96 is just what a greenhouse world would whip up. The storm was born when cold air blew down from Canada. The arctic air happened to smack into a warm, moist air mass hovering over the Atlantic Ocean. In a warmer world, those chance circumstances could be more common. "Global warming has made the Atlantic an even greater source of moisture" from evaporation, Hansen says. And when water vapor condenses, becoming liquid again, the process releases heat. So warm moist air that feeds blizzards is more likely to be parked over the Atlantic, just waiting for the delivery of a cold mass. "The greenhouse effect alters the probabilities [of having the ingredients of a massive snowstorm]," says Hansen. "In that sense the greenhouse effect is changing our climate now."

Hot Venus: Hansen was not always a greenhouse cultivator. In 1965, he was casting about for a dissertation for his Ph.D. in physics at the University of Iowa. His mentor, James Van Allen (discoverer of the radiation belts that girdle Earth), suggested that Hansen tackle the question of why the surface of Venus is hot enough to melt lead. The catch was that the explanation had to be wholly original. The best theory for Venus's heat—that it was the victim of a runaway greenhouse effect—had already been claimed by some young Harvard professor named Carl Sagan. Hansen wasn't deterred. "I decided to say that Venus was so hot because a dusty atmosphere was trapping internal heat," he recalls. That was good enough for the doctoral committee (even though it turns out that Sagan was right about Venus). Hansen received his degree and landed a fellowship at Goddard, which has lately become as well known for its location as for its science: Tom's Restaurant, where the "Seinfeld" characters chow down, is on the ground floor. Now Hansen can't escape climate change even on his birthday. For his 50th, he got a clear plastic bank filled with coins from around the world—and labeled GLOBAL CHANGE.

Some researchers resent Hansen's bravado. One June day in 1988, as drought and record heat fried the Midwest, Hansen testified before a Senate committee that he was "99 percent" certain that greenhouse warming had gone from theory to reality. The senators paid attention—it was 100 degrees in Washington that day—and Hansen became famous overnight as the government scientist who said the world was

Weathering Heights

The Weather Channel's forecast: higher ratings

WHEN IT BECAME CLEAR THE STORM WAS GOING TO BE A WHOPPER, THE Weather Channel went on a war footing. The executive producer dispatched reporters to Washington, D.C., and New York for live reports. As the storm blew furiously up the East Coast, the network stayed with it, logging news, it seemed, of almost every flake. The energy on the screen was as palpable as the blizzard outside.

Wait a minute. Isn't this the 24-hour channel of weather wonks standing in front of exotic-looking maps? It is, but just as O.J.'s was no ordinary murder trial, this was no ordinary storm—and the ratings showed it. As the blizzard developed last Sunday, more viewers tuned in to the Atlanta-based cable channel than ever before—953,000 households watched, a fourfold jump over its normal audience. That was also twice as large as the ratings for CNN, its cross-town rival in big weather stories. These ratings won't knock "ER" off its perch. But if Desert Storm fixed CNN's reputation, and O.J. did the same for Court TV, then the blizzard of '96 has put The Weather Channel solidly on the map. "We kicked CNN's butt," gushed executive producer Jim Sutherland. "We want to own the weather."

Well, not literally, but Sutherland has a right to gush. From its start in 1982, The Weather Channel has been pelted with snickers. WHEN IT RAINS IT BORES, read one headline. The male meteorologists looked like they were wearing outlet-mall suits and the women wore dresses a size too large, critics wrote. All that may have been true, but the viewing public came to want weather on demand. Buoyed by big weather stories, like Hurricane Erin last year, the channel has grown into one of the nation's "must have" cable channels. Available in over 90 percent of all cable homes, its revenues last year climbed to more than $80 million.

ADRIAN DE LUCCA

From laughingstock to must-watch: *Weathercaster*

Many viewers have turned into fanatics, some undoubtedly out of an obsession with nature and some undoubtedly because they don't have jobs. About 20 percent have reported watching for an eye-glazing 30 minutes at a time. After 14 years, TWC is a brand name, selling CD-ROMs, tornado videos and online services.

All this is pretty heady for a channel that annoyingly starts commercials while the anchorperson is still speaking. But a highly sophisticated operation churns out the forecasts. All of the channel's 27 anchors are meteorologists and, it should be said, are as well dressed and personable as any local weather broadcaster. Remarkably, they do their shtik without a script, and their passion is evident. Stu Ostro recalled that "to see hail bigger than a baseball was a very spiritual experience." At their disposal is a multimillion-dollar state-of-the-air computer system that lays out varying forecasts; the 65 meteorologists on staff make the final call. Every 10 minutes, 4,000 separate local forecasts—drawn from the National Weather Service—are beamed via satellite to local cable operators.

The channel's biggest challenge is to get people to watch longer. The fanatics aside, the average length of time a viewer watches The Weather Channel is only 14 minutes. That means the channel must move quickly to cover local, regional and national forecasts. To try to stretch that time, the channel offers features to appeal to specific audience groups, like weather for skiers. And by rapidly dissolving one map or graphic into another, the anchors keep things moving, even if the information being imparted is often the same as 15 minutes earlier. The downside is that all this can induce a trancelike state similar to watching a stock ticker tape. The antidote: the mother of all snowstorms.

LARRY REIBSTEIN *with* VERN E. SMITH *in Atlanta*

warming. Looking back on Hansen's testimony, says Kerry Emanuel of MIT, "I don't think it was good for scientific research. It was such an outlandish view that it sparked a counterrevolution. We found ourselves in the middle of the Chicken Littles on the one hand, and the reactionaries on the other." But there is little debate that, as Van Allen puts it, "Hansen's work is really the standard of reference in the field."

And lately the weather has been on his side. Downpours are one of those "extreme hydrologic events" that Hansen expects from the greenhouse. Higher temperatures mean more evaporation, which means more water vapor in the air. That does not portend more *frequent* rainfalls—whether or not a storm forms depends on circulation patterns that are not expected to shift much. But storms that do form will have more moisture-laden air to wring out. Since 1970, reports Thomas Karl of the National Climatic Data Center in Asheville, N.C., more rain in the United States has been falling in big sloppy storms, with less arriving in showers. In other words, when it rains it pours. "We were flabbergasted, to be honest with you," Karl says. "Our best information is that global warming is having an impact [on rainfall] now." It also seems to be affecting the infamous Pacific Ocean warming known as El Niño. El Niño brings torrential rain to the Southeastern United States and unusual heat to the Pacific Northwest. And global warming, says Kevin Trenberth of the National Center for Atmospheric Research, makes El Niño effects stronger and more frequent.

To scientists who remain skeptical about greenhouse warming, wacky weather and a balmier world reflect no more than normal variability. Weather is so sensitive to tiny changes, after all, that a butterfly flapping its wings in Beijing can make it rain in Pittsburgh (and if we ever find that butterfly we're going to make it stop). Need evidence that the science underlying climate models is unsettled? The IPCC now predicts that the world will warm only half as much as it forecast in 1990. The 1990 report neglected the cooling effect of sulfates, which are released into the air when dirty, high-sulfur coal and other fuels are burned; 1995's took account of sulfates. The Global Climate Coalition, an industry-sponsored group fighting efforts to require cuts in the emissions of carbon dioxide, argues that this "trend [toward lower warming estimates] could continue . . . and is a very good reason why continued research is a wise strategy." The coalition suggests that the world has 40 to 240 years to stabilize green-

house gases before the heat gets turned up uncomfortably high.

Several reputable scientists agree. There are huge uncertainties in the computerized climate models. For one, the increased evaporation in a warmer world might produce more clouds, which have a cooling effect. For another, oceans might absorb most of the increased heat, leaving little to change the climate. "I don't believe the climate system is messed up," says climatologist Robert Balling of Arizona State University. "[Neither] circulation patterns [nor] precipitation records are showing any cataclysmic problem."

The Global Climate Coalition describes its views as "business and industry's," but one player has broken ranks. Insurers have concluded that a greenhouse world could "bankrupt the industry," as the president of the Reinsurance Association of America said last year. Hurricane Andrew, the kind of storm a warmer world could see more of, produced $16.5 billion in damage claims. In Europe, reinsurers Swiss Re and Munich Re have lobbied governments to regulate greenhouse gases, and Swiss Re suggested that global warming might force people to abandon major cities. "This hazard has to be contained," says a Swiss Re statement. "We have to rethink, correct our mistakes and win time." Insurers are also meeting with Greenpeace, which is exhorting them to take on energy companies in a battle that would be straight out of a Japanese monster movie.

At the 1992 Earth Summit in Rio de Janeiro, developed nations pledged to cut their releases of greenhouse gases so that emissions in the year 2000 would not exceed 1990's. About the only country that has a chance of living up to its promise is Sweden. The United States is relying on industry to voluntarily reduce emissions—by using less energy and making more fuel-efficient cars, for instance. Rather than adopting tough measures like an energy tax, which would cut energy use but also end political careers, the United States and other countries are hoping that technology will ride to the rescue. Maybe solar power and hydrogen will replace coal and oil before greenhouse warming gets bothersome. But Hansen thinks there's less time than governments are counting on. "The climate system is being pushed hard enough that change will become obvious to the man in the street in the next decade," he says. To many people trudging along streets lined with urban Himalayas last week, it already was.

With DANIEL GLICK *in Boulder, Colo., and* ADAM ROGERS

Two Feet Under

Another crisis Washington can't handle

FOR THE BUNDLED MASSES IN CHICAGO AND BUFFALO, IT WAS AN UTTERLY INcomprehensible sight: Washington, D.C.—seat of the free world, capital of the most powerful nation on earth—trounced by one powerful dose of snow. Other cities on the East Coast got walloped, too, but they managed to clear the roads and open the stores in a few days. The capital was so poorly prepared that a week after the storm hit, nearly everyone but the president was still stuck at home. No chance of moving the car, no place open to drive to anyway. Did we in Washington think winter would just sort of *skip* us this year?

Actually, yes. And we thought it would last year, too. Every year Washingtonians brace themselves for the cold months with this neat bit of logic: Southern cities have mild winters. Washington is a Southern city. Therefore, Washington will have a mild winter. Trouble is, like so many other examples of capital reasoning, this one defies the truth: it snows here.

JOYCE NALTCHAYAN—AFP

Vigilant: *Tourists kept coming to the Vietnam wall*

At first there was something pleasantly anachronistic about the ability of mere weather to mock the determination of a city so concerned with getting to the office. The feeling didn't last long. Four days after the storm, 80 percent of the city's 1,100 miles of roads hadn't been plowed. A week after, you could still ski Pennsylvania Avenue. Residential streets were arctic preserves.

Mayor Marion Barry went on television to assure everyone that the District had plenty of equipment to get the job done. He tooled around in a plow, mugging for the cameras. (Barry could afford to be jolly; his street was cleared as soon as the snow stopped.) In fact, there wasn't nearly enough equipment. Four years ago, the District owned 100 plows and had contracts with private companies for an additional 240. By this winter, with the District broke and in federal receivership, the fleet had atrophied to a mere 50 street scrapers. Eight others stood in a downtown garage, waiting for minor parts the city hadn't ordered. To make up the shortfall, the city signed contracts with 50 private plow drivers. Barry wanted to hire more, but couldn't find any takers. No one else believed the District government would ever get around to paying them. No fools, they. In a few days the city's $2.1 million snow-removal budget was sapped. At the weekend, the mayor was begging for help.

The police, at least, could get around. The National Guard provided them with Humvees to cruise in, and at least a few cops didn't want to give them back. Not so ambulance drivers, who had to tromp for blocks through two-foot snow to retrieve the sick and injured. Firefighters had their own troubles. The hydrants were buried. Until a few years ago, a rookie fire-snuffer was required to memorize the location of every hydrant in his district. That requirement was waived; now only the old-timers know where to drag the hose.

It is hardly an exaggeration to say that in the capital of the United States of America last week, it was not possible to buy a loaf of bread. Local news stations were reduced to reading off the names of the few markets that still had milk. Surly shoppers suspiciously eyed the contents of their neighbors' carts, and made grisly jokes about getting invited to a Donner party in Georgetown.

From the darkness and chaos, however, there emerged two gratifying truths to which Washingtonians could cling. First, that violent crime in the city dropped off in the week after the storm; and second, that next year, like this one, will be a winter without snow.

WESTON KOSOVA *with* LUCY SHACKELFORD *and* PAT WINGERT *in Washington*

E. Bruce Harrison Company
Suite 300
1440 New York Avenue, NW
Washington, DC 20005
Phone: (202) 638-1200
Fax: (202) 639-8685

Facsimile Transmission Cover Sheet

DATE: December 22, 1995

NAME: Dave Banks 682- 8096
John Grasser 857-0135
Porter Womeldorff 217/422-9174

FROM: Don Rheem

TOTAL PAGES TRANSMITTED INCLUDING COVER: 8

If there is a problem with this fax transmission, please call (202) 638-1200

COMMENTS

I've just received a paper from Hugh Ellsaesser responding to what he sees as an attempt "to put a quotable statement in the peer-reviewed scientific literature that [scientists] have detected an identifiable anthropogenic signal in the observed temperature data without actually having done so..."

I'm forwarding the article to you FYI. I would like to ask Porter to check with STAC members to see if Ellsaesser's comments might be useful in our communication efforts. Should we distribute his paper to key climate change reporters? How important is the original Santer article?

[18520]

To: Don R Leam ECC 7 pages

Comment on Santer et al., "Towards the Detection and Attribution of an Anthropogenic Effect on Climate," PCMDI Report No. 21, January 1995

by

Hugh W. Ellsaesser
Participating Guest Scientist*
Atmospheric Science Division
Lawrence Livermore National Laboratory
P. O. Box 808, L-262
Livermore, CA 94550

December 1995

This paper was prepared for submission to
Climate Dynamics

*While Participating Guest Scientists are provided access to and office space in the Laboratory, they are not employees of the Laboratory. Any opinions expressed herein without attribution are strictly those of the author.

Comment on Santer et al., "Towards the Detection and Attribution of an Anthropogenic Effect on Climate," PCMDI Report No. 21, January 1995

by

Hugh W. Ellsaesser

1. Introduction.

Santer et al. (1995) are attempting to put a quotable statement in the peer-reviewed scientific literature that they have detected an identifiable anthropogenic signal in the observed temperature data without actually having done so and without even claiming to have done so. Note the language in their summary:

i. "This analysis supports but does not prove that we have detected, beyond doubt, an anthropogenic climate change signal in observed records of near-surface air temperature change."

ii. "The caveats regarding the signals and natural variability noise which form the basis of this study are numerous. Nevertheless, we have provided first evidence that both the largest-scale (global-mean) and smaller-scale (spatial anomalies about the global mean) components of a combined CO_2/anthropogenic sulfate aerosol signal are identifiable in the observed near-surface air temperature data."

iii. "While our confidence in the identification of an anthropogenic effect on climate is high, we have not shown conclusively that the signal identified can be attributed to the unique cause of anthropogenic sulfate aerosols and CO_2."

Question: if "we have not shown conclusively that the signal identified can be attributed to the unique cause of anthropogenic sulfate aerosols and CO_2," how can "the climate change signal in observed records of near-surface air temperature change" be claimed to be anthropogenic?

2. Procedure.

Santer et al. (1995) compared the model integrations of TP (Taylor and Penner, 1994) with the observational data series (updated) of Jones et al. (1991). TP used GRANTOUR (a Livermore chemistry and tracer model) coupled to the Livermore version of NCAR's CCM1 coupled in turn to a 50-meter mixed-layer ocean model to perform four equilibrium integrations: a control run (CTL) with nominal pre-industrial

CO_2 (270 ppmv); a sulfate-only run (S) with near-present-day anthropogenic sulfur emissions and pre-industrial CO_2; a CO_2-only run (C) with no sulfur emissions and nominal present-day CO_2 (345 ppmv) and a combined run (SC) with near-present-day sulfur emissions and CO_2. The TP integrations were extended for at least an additional 10 years by Santer et al. (1995).

In the analysis, a 13-year filter was passed over the 1854-1993 observational data to produce smoothed values; these were then differenced to produce seasonal and annual mean temperature change maps from some reference year, normally 1954, to 1910 to 1993. These temperature changes were then correlated year by year with the model predicted change patterns constructed by averaging the last 20 years of each model run and subtracting the control run from each of the three perturbed runs. The correlations were of two types; a centered correlation, R(t), in which the global mean is subtracted from the respective fields each year and an uncentered correlation, C(t), in which global means are not removed and only the variance of the model changes appears in the denominator.

The strategy was to search for "a long-term, positive trend in the pattern correlation statistic, which would indicate an increasing expression of the [model-predicted] signal in the observations."

3. Results.

Santer et al. (1995) found their best results in the summer and fall data. Their key finding is summed up in the following statement. "Our results indicate that in summertime (JJA) and fall (SON), the pattern of near-surface temperature change in response to combined sulfate aerosol/CO_2 forcing shows increasing similarity with observed changes over the last 50 years." There are several problems with this statement.

i. The fall trends in R(t), shown by the linear fits in their Fig. 11, are:

Trend period	Trend [century^{-1}]
50-yr (1944-93)	0.41
40-yr (1954-93)	0.32
30-yr (1964-93)	0.13
20-yr (1974-93)	-0.10
10-yr (1984-93)	-1.44

Thus, there is obviously no pattern of "*increasing similarity* with observed changes

over the last 50 years [emphasis added]." As is apparent from their Fig. 11, the 50-yr trend is determined almost entirely by the 1950-70 period. As this period is dropped out of the calculation the trend in R(t) steadily decreases and is actually negative over the last 20 years, 1974-93. This behavior is even more apparent in the R(t) curve for annual mean data.

ii. The fall value of R(t) in 1993 is about 0.22, only slightly above the initial value in 1910 of about 0.20--again very weak evidence for "increasing similarity" with time. In the annual mean data, R(t) in 1993 is well below the initial value in 1910. In fact, only for a few years around 1970 and 1985 is the annual mean R(t) ever above the initial 1910 value.

iii. The rather steady decrease in R(t) from 1910 to about 1950 is completely ignored. If we do not know the forcing function for this decrease, how can the possibility be ruled out that the 1950-70 rise in R(t) resulted merely from a reversal in this unknown forcing function?

iv. The annual mean R(t) maximizes near 0.4 circa 1970 and 1985; the fall R(t) never exceeds 0.3. Thus, at best the observed temperature changes reflect 10 to 15% of the model-predicted change patterns--and that only briefly.

4. Comparison with Other Studies.

Mitchell et al. (1995) perfomed a nearly identical but time varing study using the more sophisticated Hadley Centre coupled ocean-atmosphere climate model and a weaker (0.6 vs 0.95 W/m^2 circa 1990) and less sophisticated sulfate aerosol forcing. They ran three experiments starting from 1860: a control with constant CO_2, an experiment GHG with CO_2 increasing as recorded historically to 1990 and at 1%/yr thereafter, and an experiment SUL with both CO_2 and sulfate aerosol increasing as recorded historically until 1990 and following IPCC scenario IS92a (Houghton et al., 1992) thereafter.

The analysis was done by computing centered spatial correlations of model-predicted and observed temperature changes over each 15 x15° grid box containing at least one annual observed value. The quantities correlated were changes in decadal mean anomalies from the respective 1860-1990 means. The GHG experiment gave correlations exceeding 0.2 in the 1870s, 1880s and 1950s; other decades were near or below zero. For the SUL experiment the correlations varied about zero through the

1960s and rose to about 0.275 in the 1970s and 0.3 in the 1980s. This was interpreted as being "consistent with what could also be an emerging greenhouse gas/sulphate aerosol signal in the observations." No claim was made that an anthropogenic climate change signal had been identified in the observational data.

Note that the strongest positive trend in the centered spatial correlation was from the decade of the 1960s to that of the 1970s--essentially the same period in which Santer et al. (1995) found the strongest trend. However, the use of non-overlapping decadal means appears to have eliminated the negative correlations of 1945-55 and the rapid drop in correlations of 1985-90.

5. Interpretation of Experimental Results.

An examination of Fig. 7.10 of Houghton et al (1990) reveals that the NH becomes warmer than the SH after about 1920, reaching a maximum temperature difference circa 1950. After 1950 this temperature difference decreases, then reverses and about 1970 the SH reaches a maximum in warmth over the NH. This difference then decreases, returns to about the same value circa 1985 and then decreases rapidly to the end of the record.

Anthropogenic sulfur emissions are concentrated in the NH, thus their primary effect, as shown by the two experiments cited above, is to cool the NH relative to the SH. Since the analyses of both experiments is based primarily on centered correlations of spatial patterns (global means removed) of model-predicted and observed temperature change fields, it is no surprise that the correlation statistics for both the sulfate-only and combined experiments show marked positive trends from 1950 to 1970 -- over the period in which the hemispheric temperature difference reverses and the NH becomes colder than the SH.

The important question is the cause of this reversal in hemispheric temperature difference. Was it due to man's emissions of sulfur which apparently increased about 2-fold between 1950 and 1990 (Mitchell et al., 1995)? If so, why did the relative cooling of the NH stop in 1970 and rapidly reverse itself after 1985? The Arctic Warming of 1920-40, due presumably to a temporary acceleration of the thermohaline circulation in the N. Atlantic, is the most probable cause of the NH being warmer than the SH up to 1950. While the fading away of the Arctic Warming 1940-60 would not be expected to reverse the hemispheric temperature difference, it could have reduced it to zero.

Any attribution scenario attempting to explain the evolution of hemispheric temperature differences over this period has to invoke a large variability due to natural but unknown forcing functions. As soon as such natural variability is admitted, it cannot be eliminated from causing all of the variability leaving none to be attributed to anthropogenic forcing. Just as Santer et al. (1995) stated: "we have not shown conclusively that the signal identified can be attributed to the unique cause of anthropogenic sulfate aerosols and CO_2."

There is a final point that is worth noting. All combined sulfate and CO_2 experiments, including the Mitchell et al. (1995) experiment with a full ocean model, have shown strong polar amplification of the temperature change response. The areas of largest temperature change did not affect the computed correlations due to the paucity of observational data in polar regions. Since the satellite data show that these large polar temperature changes have failed to appear, these areas would seriously degrade the correlations of these studies if they could be included.

References,

Houghton, J. T., G. J. Jenkins and J. J. Ephraums (eds.), *Climate Change, The IPCC Scientific Assessment*, Cambridge Univ. Press, Cambridge, 1990.

Houghton, J. T., B. A. Callander and S. K. Varney (eds.), *Climate Change 1992. The Supplementary Report to the IPCC Scientific Assessment*, Cambridge Univ. Press, Cambridge, 1992.

Jones, P. D, T. M. L. Wigley and G. Farmer, Marine and land temperature data sets: A comparison and a look at recent trends. In: Schlesinger, M. E. (ed.), *Greenhouse-Gas-Induced Climatic Change: A Critical Appraisal of Simulations and Observations*, Elsevier, Amsterdam, 153-172, 1991.

Mitchell, J. F. B., T. C. Johns, J. M. Gregory and S. F. B. Tett, Climate response to increasing levels of greenhouse gases and sulphate aerosols, *Nature 376*, 501-504, 1995.

Santer, B. D., K. E. Taylor, T. M. L. Wigley, J. E. Penner, P. D. Jones and U. Cubasch, Towards the detection and attribution of an anthropogenic effect on climate, PCMDI Report No. 21, Lawrence Livermore National Laboratory, Livermore, CA, January 1995.

Taylor, K. E., and J. E. Penner, Response of the climate system to atmospheric aerosols and greenhouse gases, *Nature 369*, 734-737, 1994.

Washington Post

Infectious Disease May Rise As the World Gets Warmer

New Populations Will Be at Risk, Researchers Say

By David Brown
Washington Post Staff Writer

Global climate change over the next century may markedly increase the range of many infectious diseases, especially those spread by insects and water, according to a new report.

Malaria, with a current worldwide mortality of about 2 million people a year, may kill an additional million people annually as temperatures rise and the microbe-carrying mosquito spreads. Dengue, a painful virus infection currently in epidemic resurgence in Latin America, may move north into the United States. Warmer ocean temperatures may aid the spread of cholera in shellfish, according to the report.

"Global climate change can alter the distribution of infectious diseases, placing new and potentially large human populations at risk," wrote Jonathan A. Patz, an epidemiologist, in today's Journal of the American Medical Association.

The predictions made by Patz, of the Johns Hopkins School of Hygiene and Public Health, and his co-authors at Harvard University and George Washington University, are based on estimates that average global temperature will rise about 4 degrees Fahrenheit (2 degrees Celsius) by the year 2100. Global sea-level rise over the same period is expected to be between six inches and three feet, a change that also may increase the prevalence of infectious diseases.

A hotter environment may reduce some temperate-zone infections, such as Rocky Mountain spotted fever, but will tend to favor a larger number of tropical diseases, according to the report. Many of the latter infections are transmitted to human beings by insects and animals that will become more likely to carry infectious organisms or will spread over larger geographic areas.

Malaria, transmitted by certain species of mosquito, is the world's most prevalent "vector-borne" disease. Its spread is highly dependent on temperature and humidity, factors that affect mosquitoes' breeding.

The researchers pointed to a 1987 epidemic of malaria in Rwanda as a case study of what may occur in many areas. A high-altitude, malaria-free region experienced a large number of cases following a period of record-setting high temperatures and rainfall. In particular, small changes in minimum temperature "exponentially affected" rates of the infection, the researchers reported.

Currently, about 2 billion people in the world are at risk of contracting malaria. Should the global warming predictions prove true, an additional 620 million will be at risk by the year 2050, Patz said yesterday at a news conference here. The latter group will have none of the partial immunity conferred by repeated infection, and may tend to get more severe cases.

Dengue, a disease also known as "break-bone fever" because of the pain it causes, is also transmitted by mosquitoes and is expected to spread with higher temperatures. The effect of temperature goes beyond merely enlarging the insects' native range.

Female mosquitoes (the only sex that bites) are smaller in warmer temperatures, so they must take more blood meals in order to acquire the protein necessary to make eggs. Heat also shortens the period between the time a mosquito acquires the dengue virus and the time the virus has reproduced sufficiently for the insect's bite to transmit the disease.

"At higher temperature, the mosquito bites more often, and the bite is more likely to be infectious," Patz said.

Dengue is occasionally fatal if a person is repeatedly infected. A recent epidemic in Latin America has numbered about 140,000 cases, but has caused fewer than 100 reported deaths. An American case was diagnosed in Hidalgo County, Tex., in October. The mosquito capable of transmitting dengue exists as far north as Memphis, Patz said.

Other diseases that may become more prevalent with global warming include river blindness, whose black-fly vectors may increase in number by 25 percent in West Africa; sleeping sickness, whose tsetse-fly vectors may spread as vegetation changes in sub-Saharan Africa; and St. Louis encephalitis, a mosquito-borne disease found in the United States and elsewhere that favors warm, wet winters and hot summers.

A rise in ocean temperatures may favor the growth and spread of algae blooms, which in turn may increase the population of certain types of plankton that can carry the cholera bacterium. Warmer water also may extend the range of various "red tides" of microorganisms that can poison shellfish and people who eat them.

At the news conference, however, Patz noted that "climate is not the only factor driving these diseases." Interventions such as putting screens on windows and limiting the amount of standing water in populated areas can markedly affect disease rates, especially in developed countries such as the United States.

Among the suggestions offered by Patz and his colleagues was the establishment of "sentinel diagnostic centers" at the borders of areas where there are diseases likely to spread with global warming.

Patz's report was one of several articles on "emerging diseases" in this week's issue of the journal. One of the others described a rise of 22 percent in the number of deaths caused by infectious diseases between 1980 and 1992, excluding deaths from AIDS.

At the urging of the journal's editor, George D. Lundberg, about 35 other medical journals around the world will publish articles on emerging infections this month to heighten public and professional awareness of the problem.

DRAFT - APPROVED BY STAC

Predicting Climate Change: A Primer

Since its completion in December, 1995, the media have focused on two of the conclusions in the science portion of the IPCC's Synthesis Report,. (The IPCC is the Intergovernmental Panel on Climate Change, the UN body charged with assessing the state of knowledge on the science, impacts and economics of potential climate change.) The first conclusion is contained in the statement:

> The balance of evidence, from changes in global mean surface air temperature and from changes in geographical, seasonal, and vertical patterns of atmospheric temperature, suggest a discernable human influence on global climate.

Many media stories interpret this statement as meaning that significant human-induced climate change has already occurred, going beyond what can be justified by current scientific knowledge. The IPCC used the term "...discernable human influence..." more narrowly to indicate that some of the observed changes in temperature patterns could not be explained by normal statistical variability. Later in this paper the studies used by the IPCC to support this claim will be examined.

The IPCC recognized the limitations on our ability to attribute part or all of the climate change that has occurred over the last 120 years to human activities. The IPCC statement on the human influence on climate, contained in the Summary for Policymakers of underlying IPCC report on science, reads:

> Our ability to quantify the human influence on global climate is currently limited because the expected signal is still emerging from the noise of natural variability, and because there are uncertainties in key factors. These include the magnitude and pattern of long term natural variability and the time-evolving patterns of forcing by, and response to, changes in the concentrations of greenhouse gases and aerosols, and land surface changes. Nevertheless, *the balance of evidence suggests that there is a discernable human influence on global climate.* (emphasis added)

The second conclusion which has drawn media attention is the projection that by 2100 global average temperature will have risen by 1 - 3°C, with a best estimate of 2°C. While this statement fairly reflects the output of the best available climate models, it must be interpreted in light of the known problems with and limitations of climate models. It also should be noted that this IPCC estimate is lower by one-third than the projection the IPCC made five years ago.

This paper presents an assessment by the Global Climate Coalition's Science and Technology Assessment ~~Advisory~~ Committee of the issues in the science of climate change which relate to the ability to determine whether human emissions of greenhouse gases have had an effect on current climate or to predict whether they will have a significant impact on future climate. It is a primer on these issues, not an exhaustive analysis. Complex issues have been simplified, hopefully without any

loss of accuracy. Also, since it is a primer, it uses the terminology which has become popular in the climate change debate, even in those cases where the popular terminology is not technically accurate.

Introduction and Summary

Before discussing the climate system further, it is important to draw a distinction between climate and weather. The two are often confused. Weather is what we experience on a day-to-day or season-to-season basis. Climate is the long term average of weather. The fact that a given day sets a record for high or low temperature, or that there are a larger than usual number of named storms in the Atlantic, as occurred in 1995, is weather, and is not as indicative of a climate shift. Only a long term pattern of higher (or lower) temperatures or increased number of storms would indicate a climate shift.

Since the beginning of the industrial revolution, human activities have increased the atmospheric concentration of CO_2 by more than 25%. Atmospheric concentrations of other greenhouse gases have also risen. Over the past 120 years, global average temperature has risen by 0.3 - 0.6°C. Since the greenhouse effect can be used to relate atmospheric concentration of greenhouse gases to global average temperature, many have claimed that at least part of the temperature rise experienced to date is due to human activities, and that the projected future increases in atmospheric concentrations of greenhouse gases (as the result of human activities) will lead to even larger increases in future temperature. Additionally, it is claimed that these increases in temperature will lead to an array of climate changes (rainfall patterns, storm frequency and intensity, etc.) that could have severe environmental and economic impacts.

While the greenhouse effect is one of the factors affecting climate, it is not the only one. The intensity of solar radiation, ocean circulation patterns, volcanic eruptions, etc. also impact climate on a global scale. While we know that each of these other factors changes over time, we have little or no ability to predict their future levels.

This primer addresses the following questions concerning climate change:

1) Can human activities affect climate?

   The scientific basis for the existence of the greenhouse effect and the potential impact of human emissions of greenhouse gases such as CO_2, CH_4, N_2O, etc. on climate is well established.

2) Can future climate be predicted accurately enough for use in policy decisions?

   The climate models which are being used to estimate the increases in temperature which

might occur with increased atmospheric concentrations of greenhouse gases are limited at present both by incomplete scientific understanding of the factors which affect climate and by inadequate computational power. Improvements in both are likely, and in the next decade it may be possible to make fairly accurate statements about the impact that increased greenhouse gas concentrations could have on climate. However, these improvements may still not translate into an ability to predict future climate with a sufficient degree of accuracy for policy purposes for at least two reasons:

- limited understanding of the natural variability of climate, and
- inability to estimate future greenhouse gas emissions which will control their atmospheric concentrations.

The smaller the geographic area considered, the poorer the quality of climate projection. This is a critical limitation in our ability to project the impacts of climate change, most of which would result from changes in a local or regional area.

3) Have human activities over the last 120 years affected climate, i.e. have we been able to detect a human impact on climate?

The IPCC Synthesis Report concluded that the available evidence suggests a "discernable human influence on global climate." As indicated above, this conclusion is subject to considerable uncertainty, and, in fact, is at odds with statements contained in the report of IPCC Working Group I on Science and accepted by governments at the December, 1995 IPCC Plenary Meeting, for example:

> Finally we come to the most difficult question of all: "When will the detection and unambiguous attribution of human-induced climate change occur?" In the light of the very large signal and noise uncertainties discussed on this Chapter, it is not surprising that the best answer to this question is "We do not know." Some would and have claimed, on the basis of the results on Section 8.4 that detection of a significant climate change has already occurred. Few if any would be willing to argue the unambiguous *attribution* of this change to anthropogenic effects has already occurred, or was likely to happen in the next several years.

<u>The Climate System</u>

The Sun warms the Earth and is the source of energy for the climate system. However, as shown in Figure 1, the process by which this occurs is complicated. Only about half of the incoming radiation from the Sun is absorbed by the Earth's surface. About a quarter is absorbed by the atmosphere, and the remainder is reflected back into space either by the Earth's surface, or by clouds, dust and other particulates, without being absorbed.

The energy absorbed by the Earth's surface is reradiated to space as longwave radiation. A fraction of this reradiated energy is absorbed by greenhouse gases, a phenomenon known as the greenhouse effect. Greenhouse gases are gases - such as water vapor, CO_2, methane, etc. - which have the ability to absorb longwave radiation. When a greenhouse gas molecule absorbs longwave energy, it increases in temperature, then radiates energy in all directions, including back down to the Earth's surface. The energy radiated back to the Earth's surface by greenhouse gas molecules is the greenhouse effect that further warms the surface. The warmer the surface of the Earth, the more energy it reradiates. The higher the concentration of greenhouse gases, the more energy they will absorb, and the more they will warm the Earth. The average temperature of the Earth depends on the balance between these two phenomena. Naturally occurring greenhouse gases, predominantly water vapor, account for 95-97% of the natural greenhouse effect. They raise the average temperature of Earth's surface by about 30°C. Without this natural greenhouse effect, the Earth would be uninhabitable. The science of the greenhouse effect is well established and can be demonstrated in the laboratory.

Natural Climate Variability

The climate system has natural variability, on both long and short time scales. The existence of Ice Ages and the warm periods between them is proof of climate's natural variability on very long time scales. But climate is also naturally variable on shorter time scales. For example, the relatively mild temperatures in the North Atlantic at about 1000 AD were followed by the colder temperatures of the Little Ice Age after 1400. This was climate variability on a time scale of several centuries. To determine whether future climate changes are the result of human activities or attributable to natural variability, we need a good estimate of the natural variability of climate on still shorter periods, decades to a century, which is currently unavailable.

Understanding the natural variability of climate on a decadal time scale and its causes would greatly improve our understanding of current climate data. Reasonable temperature records exist for only the last 120 years. Data on factors which could be causes for the variability of climate, such as changes in ocean circulation, are either non-existent or available for much shorter time periods.

It is possible that the natural variability of the climate system is so large that we may never be able to predict its behavior a century in the future with sufficient accuracy to be useful for policy purposes. Even though global climate has been fairly stable for much of the last 10,000 years, studies of ice cores from Greenland indicate that before then there were large climate shifts in periods as short as a few decades.

The IPCC Synthesis Report discusses the possibility that it may be impossible to make long

term predictions about climate as follows:

> There are many uncertainties and many factors currently limit our ability to project and select future climate change. Future unexpected, large and rapid climate system changes (as have occurred in the past) are, by their nature, difficult to predict. This implies that future climate changes may also involve "surprises."

Can Human Activities Affect Climate?

Human activities can affect the energy balance at the Earth's surface in three ways:

- combustion, agriculture and other human activities emit greenhouse gases and can raise their concentration in the atmosphere, which would directionally lead to warming;
- combustion emits particulates, and gases such as sulfur dioxide which form particulate matter in the atmosphere, which would directionally lead to cooling; and
- changes in land-use, such as removing forests, can change the amount of energy absorbed by the Earth's surface, the rate of water evaporation, and other parameters involved in the climate system, which could result in either warming or cooling.

These three factors create the potential for a human impact on climate. While, in theory, human activities could result in net cooling, driving the climate towards a new Ice Age - - a concern about 25 years ago- - the current balance between greenhouse gas emissions and the emissions of particulates and particulate-formers is such that essentially all of today's concern is about net warming. However, as will be discussed below, it is still not possible to accurately estimate the magnitude (if any), timing or impact of climate change as a result of the increase in greenhouse gas concentrations. Also, because of the complex, possibly unpredictable, nature of the climate system, it may never be possible to project future climate or the impact of increased greenhouse gas concentrations with sufficient accuracy to be useful for policy purposes.

The usual approach to discussing the impact of the increased atmospheric concentrations of greenhouse gases on climate is to convert them to an equivalent amount of CO_2, then discuss the effect of some fixed increase in equivalent CO_2. Most of the discussion is about doubled equivalent CO_2. The conversion to equivalent CO_2 introduces a number of errors, because the effects of some greenhouse gases depend on their location in the atmosphere, but since the convention is well established, it will be used in this discussion. A more accurate approach is to refer to increased radiative forcing, which is the increase in energy radiated to the Earth's surface, taking into account all of the complexities in the physics of greenhouse gases.

Do We Have the Tools to Accurately Project Future Climate?

Climate models are used to estimate the change in temperature, rainfall, cloud cover and other climate parameters that would result from a change in equivalent CO_2 and sometimes aerosols. The estimates of climate parameters are then used to estimate impacts of climate change, such as frequency and severity of tropical storms, effects on agriculture and biodiversity, etc. While most discussions of models focus on their estimations of changes in average temperature, factors such as changes in maximum and minimum temperature, soil moisture content, and prevalence of conditions which influence the formation of tropical storms are far more important in determining potential climate change impacts.

The most sophisticated climate models are coupled atmosphere-ocean general circulation models (coupled GCMs). These are three-dimensional grid models which cover the whole Earth, the atmosphere to a sufficient height to include all climate processes, and the oceans in multiple depth layers. Most of the debate about the estimation of climate change centers around the quality of both the models and the input data they use, and the degree to which both can be improved. The concerns about these models can be grouped into four categories:

(1) limits in scientific understanding of climate processes,

(2) how they model "feedbacks,"

(3) how they describe the initial conditions, i.e., the current state of the climate, and

(4) the computational power required to accurately model climate.

A fifth concern, not directly related to coupled GCMs, but important to the question of whether future climate can be accurately estimated, is whether future atmospheric concentrations of greenhouse gases can be accurately estimated. The problem has two components, economic and scientific. The economic question is whether we can accurately estimate both the future level of global economic activity and the technology which will be employed. Past estimates in both areas have been highly inaccurate. The scientific question is whether we understand the fate of greenhouse gases well enough to accurately project the effect their emissions will have on atmospheric concentrations. For example, only about half of the CO_2 emitted from human activities ends up in the atmosphere. The remainder is believed to be absorbed by increased plant growth or in the oceans. Estimates of the amount of CO_2 absorbed by these two sinks are highly uncertain. There is also a great deal of scientific debate on what, if any, impact higher temperatures and related climate change will have on the rate of CO_2 absorption by plants and the ocean.

Limited Scientific Understanding of Climate Processes

Quantifying what we don't know about climate processes is an impossible task. However, the huge volume of important new findings about the processes that are critical to climate generated over the past few years make it obvious that there is a great deal more to be learned about the basic science of climate. For example, in 1995, Prof. Robert Cess and his co-workers at the State University of New York published a paper on the energy balance around clouds which indicated that the values being used in climate models were incorrect by 25%. Cess *et al.* were unable to identify the physical processes which led to this different estimate of energy absorption. Since clouds are a critical part of the climate system, a correct characterization of their properties is essential. Other recent studies indicate that vegetation may be absorbing much more CO_2 than previously believed, allowing less of it to accumulate in the atmosphere.

Feedbacks

Climate models estimate that the direct effect of doubling equivalent CO_2 from pre-industrial levels is relatively small. Global average temperature would rise by 0.5 - 1°C, an amount which is not generally considered to represent a problem. However, even that rise in temperature would cause a variety of changes, some of which would act to further increase temperature, others of which would act to decrease temperature. These secondary changes are called "feedbacks." The popular usage is that a positive feedback is one which acts to further increase temperature, and a negative feedback is one which acts to decrease temperature. The technical definition is that a positive feedback is one which exaggerates the initial perturbation, which could either increase or decrease temperature, and a negative feedback is one which decreases the initial perturbation. Since the popular usage is so common, it will be used in this paper.

The most important positive feedback is the impact which rising temperatures will have on the amount of water vapor in the atmosphere. Water vapor is the most important natural greenhouse gas in the atmosphere, accounting for the majority of the natural greenhouse effect. As temperature increases, more water evaporates, the concentration of water vapor in the atmosphere rises, the greenhouse effect is enhanced, and temperatures rises further. An example of a negative feedback is that more evaporation of water results in the formation of more clouds. Low level clouds reflect sunlight, preventing its energy from reaching the Earth's surface, thus providing a cooling effect. As noted below, high level clouds provide a positive feedback.

Modeling feedbacks is one the major challenges in developing accurate climate models. The role of clouds is a particularly difficult modeling task. Low level clouds reflect sunlight and therefore are a negative feedback. However, clouds are made up of water vapor and therefore

also absorb radiation. For high level clouds the absorption of radiation is more important than the reflection of radiation; they provide a positive feedback. Better estimates of the energy balance around clouds are becoming available, and preliminary modeling results indicate that the use of these better estimates improves the ability of coupled GCM's to match current conditions.

Simulation of Current Conditions

An ideal coupled GCM would be theory-based and able to match current climate conditions using only the independent variables that determine climate (solar radiation, greenhouse gas and aerosol concentrations, the current temperature of the oceans, etc.) as inputs. Current coupled GCMs do not meet this goal because they do not accurately calculate the transfer of energy between the oceans and the atmosphere, a critical climate parameter. To correct this error, most coupled GCMs are adjusted with "flux corrections," that on a point-by-point basis adjust the amount of heat being transferred from the oceans to the atmosphere to match actual conditions. The "flux corrections" can be quite large, as much as 10 - 20 times the effect of doubling equivalent CO_2. Having to make this large a correction to obtain model results which provide a reasonable description of the baseline is a cause for serious concern.

The IPCC shares this concern about flux corrections, and in its underlying report on science makes the following statement:

> Flux adjustment is strictly justified only when the corrections are relatively small and in fact the flux adjustments in some coupled models are comparatively large. The alternative is to avoid flux adjustment and accept the resulting climate drift, a choice that is made in several of the models listed in Table 5.1. However, the confidence in a coupled model's simulation of transient climate change is not improved if the climate drift is large and/or the feedbacks are seriously distorted by flux adjustment.

Flux corrections are correcting for one of two possible errors: missing climate processes, or errors in the description of the climate processes used in the model. New data, such as a better description of the energy balance around clouds, should lead to improvements in models and a reduction in the flux corrections.

Whether modeling capability will improve to the point where the flux corrections can be eliminated or reduced to a more reasonable level is an open question. To eliminate the flux corrections it is necessary to accurately model all climate processes and have an accurate description of initial conditions. Distribution of heat in the oceans is poorly understood, and the cost of collecting the necessary data makes it unlikely that a better understanding will be developed anytime soon.

Computational Limits

Coupled GCMs are such complex models that it requires several months of supercomputer time to provide a full projection of 100 years of global climate. Computational limitations require that they use large grid sizes, typically 500 km. on a side. These cells are larger than many of the important physical features in the system they are trying to model, for example, the width of the Gulf Stream. Computational limits also mean that some critical factors, such as the atmospheric interactions between greenhouse gases and the chemistry of aerosol formation, are not included in the model. The rapid increase in computational power may make it possible to overcome these limitations in the future, but at present they severely limit the quality of coupled GCM projections.

Capabilities of Coupled GCMs

Even with flux corrections, coupled GCMs still cannot accurately describe climate features on a 1000 mile scale which are critical to any discussion of the impacts of climate change. Also, there is considerable concern about the ability of coupled GCMs to estimate future climate because the flux correction is constant with changing equivalent CO_2. There is no reason to assume that the flux correction should remain the same if climate changes in response to increased atmospheric levels of greenhouse gases. The IPCC estimates that doubling equivalent CO_2 would increase global average temperature by 1.5 - 4.5°C. More specific estimates do not seem justified.

Improvements in climate model capability are possible. Better understanding of climate processes, such as the role of clouds, could significantly improve the models as could the ever increasing power of computers. Whether we can ever accurately estimate future climate is still uncertain because of two problems. First, as mentioned above, climate may be unpredictable. Second, even if climate is predictable, a model's estimations are only as good as the input data used. Our ability to estimate future greenhouse gas emission rates depends on being able to project the future level of global economic activity and the technology which will be used to generate that activity. Past projections in both areas have been highly inaccurate.

IPCC recognized the difficulty in projecting future greenhouse gas emission rates, and has not done so. Instead they have constructed six scenarios, which differ in rate of population growth, economic activity and dependence on fossil fuels. These scenarios give widely differing projections of future greenhouse gas emissions and the time to reach given atmospheric concentrations of greenhouse gases. Most of the discussion of the IPCC's work has focussed on the "business-as-usual" scenario, which assumes that the trends which have occurred in the recent past, including a moderate rate of energy efficiency improvement, will continue to 2100. The focus on this one scenario has obscured the fact that it is not a prediction, but simply one of six cases the IPCC chose to study. Even naming the scenario as

"business-as-usual" can lead to confusion. Nothing in economic history indicates that recent trends can be expected to continue for the next 100 years.

Another critical problem in climate modeling is the prediction of regional climate change. Most of the impacts of climate change will be felt on the regional or local level. The change in global average temperature and rainfall will not help estimate the effect of climate change on farmers in the mid-West. The ability to project regional climate change is poorer than the ability to project global climate change. The IPCC sums up the situation as follows:

> Confidence is higher in hemispheric-to-continental scale projections of coupled atmospheric-ocean models than in the regional projections, where confidence remains low.

Have Human Activities Over the Last 120 Years Affected Climate?

The IPCC Synthesis Report contains the following conclusion:

> The balance of evidence, from changes in global mean surface air temperature and from changes in geographical, seasonal, and vertical patterns of atmospheric temperature, suggest a discernable human influence on global climate.

As an intergovernmental organization, final IPCC decisions are made by government representatives. This can result in summary statements that are stronger than the statements in the underlying report, which are written and edited by working group members, most of whom are academics. The statement in the underlying report addressing the detection of a human impact on climate reads:

> Any claims of positive detection and attribution of significant climate change are likely to remain controversial until uncertainties in the total natural variability of (the) total climate system are reduced. (1)

---

(1) As used by the IPCC,

> "Detection of change" is the process of demonstrating that an observed change in climate is highly unusual in a statistical sense, but does not provide a reason for the change. "Attribution" is the process of establishing cause and effect relations, including the testing of competing hypotheses.

IPCC Working Group I (WG I) considered four types of information in evaluating whether the observed change in climate was in fact "highly unusual in a statistical sense," and whether it could be attributed to human influences. A discussion of each type of information follows. Specific scientific studies are mention in three cases; they are the studies which have received the most publicity, but are not the only studies in the category.

1) Model-based estimates of natural variability - The Max Planck Institute (MPI), a German government laboratory and developer of one of the GCMs, ran their model for 1000 years into the future with only random perturbations to assess "natural" variability of temperature. They then determined, with 95% confidence, that the changes in temperature observed over the last 100 years could not be explained by their measure of "natural" variability. German politicians and press have reported this result as meaning that there is 95% confidence that the temperature changes of the last 100 years have been caused by human emissions of greenhouse gases, a significant overstatement of the scientific finding.

   The MPI finding does not prove that the temperature changes of the last 100 years are due to human greenhouse gas emissions for two reasons:

   - Models are simplifications and therefore less variable than the real world. Actual "natural" variability of temperature is almost certain to be larger than the estimate from the MPI computer study.

   - The temperature change of the past 100 years may be due to natural changes in climate. Changes of this magnitude have occurred naturally in the past without any human influence. Section 3.6.3 of IPCC WG I's contribution to the Second Assessment Report states:

     > The warming of the late 20th century appears to be rapid, when viewed in the context of the last millennium. But have similar, rapid changes occurred in the past? That is, are such changes a part of the natural climate variability? Large and rapid changes did occur during the last ice age and in the transition toward the present Holocene period which started about 10,000 years ago. Those changes may have occurred on the time scale of a human life or less, at least in the North Atlantic, where they are best documented. Many climate variables were affected: atmospheric temperature and circulation, precipitation patterns and hydrological cycle, temperature and circulation of the ocean.

2) Pattern-based studies - The Hadley Centre, a U.K. government laboratory and the developer of another GCM, has added sulfate aerosol effects to its model and estimated

temperature from 1860 to 2050. The addition of aerosol effects provides an improved, but still relatively poor, match for observed temperature from 1860 to the present, and addresses one of the key concerns about climate models, their inability to "backcast" the temperature record. The study ties the increase in temperature over the past 100 years to emissions of greenhouse gases and aerosols.

There are two concerns about the Hadley Centre's work:

- They considered only the direct effect of sulfate aerosols, i.e., their scattering of incoming sunlight. They did not consider the indirect effects of the aerosols - their impact on cloud formation - which could have an equally large impact on temperature.

- Adding historical sulfate aerosol effects to the model requires a large number of assumptions about fuel usage rates and emission factors which cannot be tested. This approach adds to the uncertainty in the model projections.

  IPCC WG I's report discussed the Hadley Centre study and similar work and concluded:

  > While some of the pattern-based studies discussed here have claimed detection of a significant climate change, no study to date has positively attributed all or part of that change to anthropogenic causes. Nor has any study quantified the magnitude of a greenhouse gas effect or aerosol effect in the observed data ...

3) Studies of the vertical temperature profile of the atmosphere - Climate models project that an increase in greenhouse gases should lead to a warmer troposphere but a cooler lower stratosphere. The fact that this pattern has been observed is being used to argue for the fundamental correctness of climate models and for the validity of their projections that human emissions of greenhouse gases will cause changes in climate. IPCC WG I's part of the Second Assessment Report (Section 8.4.2.1) cites two studies which could be interpreted as supporting this conclusion.

However the observed vertical temperature profile may be due to stratospheric ozone depletion rather than to the buildup of greenhouse gases in the troposphere. If stratospheric ozone depletion is a factor, it is "a human forcing of climate" but a different one from the buildup of greenhouse gases in the troposphere. Model agreement with the stratospheric ozone effect does not "prove" that the model is correct in projecting the effects of greenhouse gases in the troposphere.

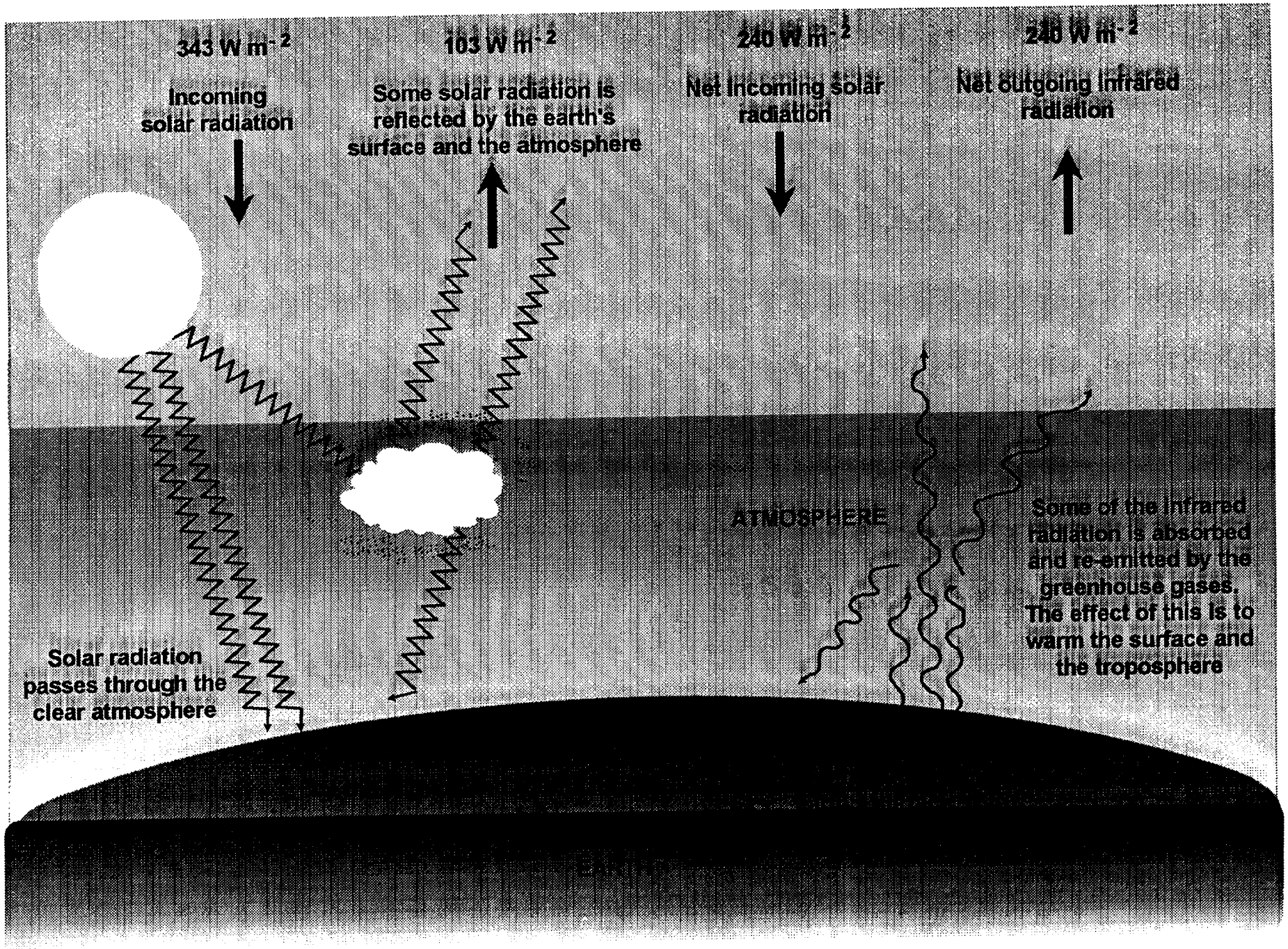
4) Statistical models fitted to observations - T. R. Karl and three other researchers at National Climatic Data Center (NCDC) evaluated U.S. climate data since 1910 using an index of specific weather events, designated USGCRI, which included: above normal minimum temperatures, above normal precipitation from October to April, below normal precipitation from May to September, and a greater than normal proportion of precipitation coming from heavy rainfalls. These are the types of climate "signature" that many scientists believe will be the first indication of climate change. Karl *et al.* concluded:

> The tendency towards increased values of the USGCRI over the past two decades is suggestive of a climate driven by greenhouse warming. At the same time, however, statistical analysis indicates that because the change is neither large enough nor consistent enough through time, one cannot unequivocally reject the possibility (about a 5 -10% chance) that the increase is still a feature of a stable climate.

Karl *et al.*'s choice of factors for the NCDC index may be questioned, since the index is strictly empirical and has not been developed from basic principles. However, the parameters in the index are variables which other researchers have claimed could change as the result of climate change. As in the case of the other studies claiming to show that there has already been a human impact on climate, one can question whether the observed changes are the result of greenhouse gases or other climate influences.

To summarize, claims that human activities have already created a significant impact on climate, seem unsubstantiated given the many limitations and uncertainties in the studies used to support those claims.

primer2.wp6


343 W m-2
Incoming solar radiation
103 W m-2
Some solar radiation is reflected by the earth's surface and the atmosphere
240 W m-2
Net incoming solar radiation
240 W m-2
Net outgoing infrared radiation
ATMOSPHERE
Some of the infrared radiation is absorbed and re-emitted by the greenhouse gases. The effect of this is to warm the surface and the troposphere
Solar radiation passes through the clear atmosphere

DRAFT 2/15/96 DRAFT FOR GCC REVIEW AND DISCUSSION ONLY

Draft GCC Statement In Support of
Global Climate Scientific and Economic Research

The Global Climate Coalition strongly urges that the administration and Congress place a highest priority on scientific research to advance the understanding of earth systems, introduction of new knowledge into climate models, and refinement of the tools necessary for decision-making with respect to the long-term economic strategies necessary to address potential climate change.

The understanding of global climate has evolved significantly over the past decade. Over just the last five years, as evidenced by a comparison of the findings of the Intergovernmental Panel on Climate Change's First and Second Assessment Reports, the net effect of greater knowledge has been to lower climate impact projections of a "business-as-usual" scenario — about a one-third lower impact for temperature change and about a one-fourth lower impact for sea level change.

Despite significant research, the range of uncertainty in key aspects of climate change assessment remains high. A careful reading of the IPCC's Second Assessment Report indicates the many significant uncertainties that remain in the basic science, climate modeling, and economic assessments of climate change. As noted in the IPCC Working Group I report (page 8.18), "no study to date has positively attributed all or part of the [historic temperature] change to anthropogenic causes. Nor has any study quantified the magnitude of a greenhouse-gas effect or aerosol effect in the observed data--an issue that is of primary relevance to policymakers."

At the same time, a growing body of analysis indicates that information that reduces uncertainty may provide significant benefits. With inadequate understanding and knowledge, society may attempt to protect itself against apparently low probability but theoretically possible events that might have large future impacts. Resolving uncertainty about the true nature of the climate change threat allows for more efficient timing of any necessary mitigation and adaptation policies, and avoids unfounded and expensive reactions that may ultimately prove unnecessary. Some studies estimate that improved information about climate change issues is worth perhaps hundreds of billions of dollars (in present value terms) to society. Working Group III of the Intergovernmental Panel on Climate Change came to a similar conclusion when it stated in its Summary for Policymakers that "The value of better information about the processes, impacts of and responses to climate change is likely to be great."

In short, improved information about basic science, modeling, and potential climate change policies is vital. Critical issues include, but are not limited to: how earth's systems work; how new and better knowledge about earth's systems can be incorporated into climate models; how changes in climate may impact society and ecosystems; how social, technological and environmental change as well as adaptation can be integrated into appropriate baseline scenarios; and how the potential benefits and costs of government policies over an extended time-frame can be adequate assessed. Improved information about the functioning of climate and the policies that might address mitigation or adaptation strategies over the long-term has many of the characteristics of what economists call "public goods," and this places a large burden on the financing of climate change research on governments.

Forthcoming in May 1996

Climate Change 1995

The Intergovernmental Panel on Climate Change (IPCC) was set up jointly by the World Meteorological Organization and the United Nations Environment Programme to provide an authoritative international consensus of scientific opinion on climate change. The IPCC prepared its first comprehensive assessment report in 1990, with subsequent supplementary reports in 1992 and 1994. *Climate Change 1995* is the first full sequel to the original assessment. The IPCC's periodic assessments of the causes, consequences and possible responses to climate change are the most comprehensive and up-to-date available. These assessments form the standard scientific reference for all concerned with climate change and its consequences, in academia, government and industry worldwide. Several hundred scientists and contributors, recognized internationally as experts in their fields, were brought together in three working groups to assess climate change for this Second Assessment Report. During drafting, the chapters were exposed to extensive review by many other independent experts, and subjected to full governmental reviews. Three volumes from the IPCC are produced under the umbrella title *Climate Change 1995*. For the first time, all three volumes are published by Cambridge University Press:

Climate Change 1995 The Science of Climate Change

Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change

Editors J.J. Houghton, L.G. Meiro Filho, B.A. Callander, N. Harris, A. Kattenberg and K. Maskell.

1996 448pp.

564336	Hardcover	Approx List: $80.00*	Discount: $64.00*
564360	Paperback	Approx List: $29.95*	Discount: $23.96*

Climate Change 1995 Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analyses

Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change

Editors R.T. Watson, M.C. Zinyowera, and R.H. Moss.

1996 880pp.

56431X	Hardcover	Approx List: $94.95*	Discount: $75.96*
564379	Paperback	Approx List: $37.95*	Discount: $30.36*

Climate Change 1995 Economic and Social Dimensions of Climate Change

Contribution of Working Group III to the Second Assessment Report of the Intergovernmental Panel on Climate Change

Editors J. Bruce, Hoesung Lee and E. Haites.

1996 608pp.

560519	Hardcover	Approx List: $94.95*	Discount: $75.96*
568544	Paperback	Approx List: $37.95*	Discount: $30.36*

SPECIAL 20% DISCOUNT ORDER FORM

Offer valid through March 31, 1996 **Prices good for this order form only*

Climate Change 1995 - The Science of Climate Change	__ 564336	Hardcover	Discount: $64.00*
	__ 564360	Paperback	Discount: $23.96*
Climate Change 1995 - Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analyses	__ 56431X	Hardcover	Discount: $75.96*
	__ 564379	Paperback	Discount: $30.36*
Climate Change 1995 - Economic and Social Dimensions of Climate Change	__ 560519	Hardcover	Discount: $75.96*
	__ 568544	Paperback	Discount: $30.36*

TERMS OF THE OFFER. All individual orders must be prepaid by check or money order or charged on VISA or MasterCard (libraries excepted). The use of a credit card will expedite your order. Canadian residents please add 7% GST. Shipping and handling charges in North America are $3.50 for the first book; $0.75 for each additional book.

Name _____
Address _____
City _____
State/Prov. _____ ZIP _____
Institution/Affiliation _____
[ ] Payment Enclosed $_____ [ ]VISA [ ] MasterCard
Charge Card Number_____-_____-_____-_____
Expiration Date_____

Total discount prices from above $_____
Add NY/Calif. sales tax $_____
Canadians add 7% GST $_____
Add shipping charge $_____
Net total $_____

Signature _____

Return to: Dept. PJL fax (212) 691-3239
CAMBRIDGE UNIVERSITY PRESS • 40 WEST 20TH STREET • NEW YORK, NY 10011-4211

GLOBAL CLIMATE CHANGE SCIENCE -- OVERVIEW OF RECENT DEVELOPMENTS

JOHN KINSMAN
EDISON ELECTRIC INSTITUTE

EEI ENVIRONMENT & ENERGY COMMITTEE
MONTEREY, CALIFORNIA

13 FEBRUARY 1996

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC)

- PERCEIVED TO PRODUCE THE STATE-OF-THE-ART ASSESSMENTS
- FIRST ASSESSMENT REPORT IN 1990
- THREE WORKING GROUPS:
  - WG I -- SCIENCE
  - WG II -- IMPACTS, ADAPTATION AND MITIGATION OPTIONS
  - WG III -- SOCIO-ECONOMICS
- DECEMBER 1995 -- SECOND ASSESSMENT REPORT APPROVED

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC)

- PERCEIVED TO PRODUCE THE STATE-OF-THE-ART ASSESSMENTS
- FIRST ASSESSMENT REPORT IN 1990
- THREE WORKING GROUPS:
  - WG I -- SCIENCE
  - WG II -- IMPACTS, ADAPTATION AND MITIGATION OPTIONS
  - WG III -- SOCIO-ECONOMICS
- DECEMBER 1995 -- SECOND ASSESSMENT REPORT APPROVED

IPCC SECOND ASSESSMENT REPORT

- 50 *CHAPTERS* (1900+ PAGES) WRITTEN AND REVIEWED BY 2000 EXPERTS
- *SUMMARY FOR POLICYMAKERS (SPM)* -- WRITTEN BY MIX OF SCIENTISTS AND POLICYMAKERS, REVISED/APPROVED BY GOVERNMENTS
- *SYNTHESIS REPORT*
  - WRITTEN BY 25 MOSTLY POLICYMAKERS, REVISED/APPROVED BY GOVERNMENTS
  - DRAWS TOGETHER SPM RESULTS PLUS ADDRESSES ARTICLE 2 OF THE FCCC, WHICH CALLS FOR:

    "STABILIZATION OF GREENHOUSE GAS CONCENTRATIONS IN THE ATMOSPHERE AT A LEVEL THAT WOULD PREVENT DANGEROUS ANTHROPOGENIC INTERFERENCE WITH THE CLIMATE SYSTEM"

SCIENCE -- BASICS

- GREENHOUSE EFFECT IS NATURAL AND BENEFICIAL
- REAL CONCERN IS MAN-INDUCED ENHANCED GREENHOUSE EFFECT
- GHG EMISSIONS AND CONCENTRATIONS ON THE RISE
- GLOBAL MEAN TEMPERATURE UP 0.3-0.6 DEGREES C OVER PAST CENTURY, BUT WITHIN BOUNDS OF NATURAL CLIMATIC VARIABILITY
- GLOBAL MEAN TEMPERATURE INCREASE 1.5-4.5 DEGREES C WITH $2XCO_2$
- AEROSOLS, EL NINO AND VOLCANIC ERUPTIONS IMPORTANT
- MODELS TO PREDICT FUTURE QUITE LIMITED -- HOW MUCH, WHERE AND WHEN KNOWN WITH LITTLE CONFIDENCE
- NO CONFIDENCE PREDICTING REGIONAL CLIMATE CHANGE
- IMPACT STUDIES SCATTERED AND HIGHLY UNCERTAIN

IPCC SECOND ASSESSMENT REPORT -- KEY NEW FINDINGS/PREDICTIONS

- TEMPERATURE AND SEA LEVEL RISE PREDICTIONS ADJUSTED DOWNWARD
- MAN'S INFLUENCE ON GLOBAL CLIMATE "DISCERNIBLE"
- IMPACTS -- THREATENING PREDICTIONS, ESPECIALLY REGARDING HUMAN HEALTH
- NO PROOF OF WIDESPREAD INCREASINGLY VARIABLE CLIMATE, BUT SOME PLAUSIBLE THEORIES OF GREATER EXTREMES IN FUTURE

TEMPERATURE AND SEA LEVEL

OBSERVED DURING LAST 100 YEARS

- TEMPERATURE -- 0.3-0.6 DEGREES C INCREASE (GLOBAL MEAN)
- SEA LEVEL -- 10-25 CM RISE, WITH "MUCH OF THE RISE MAY BE RELATED TO THE INCREASE IN GLOBAL MEAN TEMPERATURE"

TEMPERATURE AND SEA LEVEL

PREDICTED CHANGE BY 2100 (FROM 1990)

- TEMPERATURE
  - 1.0-3.5 DEGREES C INCREASE (GLOBAL MEAN)
  - BEST ESTIMATE OF 2.0 DEGREES C INCREASE IS 33% LOWER THAN IN 1990 IPCC REPORT
  - IN ALL CASES, THE AVERAGE RATE OF WARMING WOULD PROBABLY BE GREATER THAN ANY SEEN IN PAST 10,000 YEARS
- SEA LEVEL
  - 15-95 CM (AT TIME OF CO_2 DOUBLING/ CONTINUED INCREASE AFTERWARDS)
  - BEST GUESS OF 50 CM IS 25% LOWER THAN IN 1990 IPCC REPORT

MAJOR UNCERTAINTIES WITH IPCC PREDICTIONS OF THE FUTURE

- ESTIMATION OF FUTURE EMISSIONS -- REQUIRES KNOWLEDGE OF ECONOMICS, POPULATION, TECHNOLOGIES, AS WELL AS THE UPTAKE BY LAND PLANTS AND OCEANS OF CO_2
- REPRESENTATION OF CLIMATE PROCESSES IN MODELS, ESPECIALLY FEEDBACKS
- UNDERSTANDING OF NATURAL VARIABILITY

ANTHROPOGENIC INFLUENCE ?

IPCC SYNTHESIS REPORT:

- 0.3-0.6 DEGREES C GLOBAL INCREASE IS "A CHANGE UNLIKELY TO BE ENTIRELY NATURAL IN ORIGIN"
- "THE BALANCE OF EVIDENCE... SUGGESTS A DISCERNABLE HUMAN INFLUENCE ON GLOBAL CLIMATE. THERE ARE UNCERTAINTIES IN KEY FACTORS, INCLUDING THE MAGNITUDE AND PATTERNS OF LONG-TERM NATURAL VARIABILITY."
- U.S. -- NOAA RESEARCH FINDS THE CHANCE OF CHANGES SINCE 1976 BEING PURELY NATURAL IS 1-20%

ANTHROPOGENIC INFLUENCE ?

IPCC WG I -- CHAPTER 8:

- "LARGE UNCERTAINTIES STILL APPLY TO CURRENT ESTIMATES OF THE MAGNITUDE AND PATTERNS OF NATURAL CLIMATE VARIABILITY, PARTICULARLY ON THE DECADAL- TO CENTURY-TIME SCALES THAT ARE CRUCIAL TO THE DETECTION PROBLEM"

- "WHEN WILL AN ANTHROPOGENIC EFFECT ON CLIMATE BE IDENTIFIED?
  - WE DO NOT KNOW
  - FEW IF ANY WOULD BE WILLING TO ARGUE THAT UNAMBIGUOUS ATTRIBUTION OF THIS CHANGE TO ANTHROPOGENIC EFFECTS HAS ALREADY OCCURRED, OR IS LIKELY TO HAPPEN IN THE NEXT SEVERAL YEARS"

OTHER POINTS

- A SMALL CHANGE THAT IS ALMOST MEANINGLESS IN THE REAL WORLD CAN BE STATISTICALLY SIGNIFICANT

- MANY WILL CLAIM THIS "DETECTION OF A DISCERNIBLE INFLUENCE" AS A WATERSHED EVENT AND USE THIS AS REASON TO ARGUE FOR A PROTOCOL BEFORE THE AGBM

PREDICTED ENVIRONMENTAL IMPACTS -- GENERAL

- MIX OF ADVERSE IMPACTS, SOME POTENTIALLY IRREVERSIBLE, AND SOME BENEFICIAL IMPACTS
- COMPOSITION AND GEOGRAPHIC DISTRIBUTIONS OF MANY ECOSYSTEMS WILL SHIFT
- CLIMATE CHANGE IS AN ADDITIONAL STRESS ON TOP OF POLLUTION, INCREASED RESOURCE DEMANDS AND NONSUSTAINABLE MANAGEMENT PRACTICES

ENVIRONMENTAL IMPACTS -- GENERAL UNCERTAINTIES

- QUANTITATIVE PREDICTIONS OF IMPACTS FOR ANY PARTICULAR SYSTEM AT ANY PARTICULAR LOCATION ARE DIFFICULT BECAUSE:
  - REGIONAL-SCALE CLIMATE CHANGE PREDICTIONS ARE UNCERTAIN
  - UNDERSTANDING OF MANY CRITICAL PROCESSES IS LIMITED
  - SYSTEMS ARE SUBJECT TO MULTIPLE CLIMATIC AND NON-CLIMATIC STRESSES
  - FEW STUDIES HAVE CONSIDERED DYNAMIC RESPONSES
- UNAMBIGUOUS DETECTION OF CLIMATE-INDUCED CHANGES IN MOST ECOLOGICAL AND SOCIAL SYSTEMS WILL PROVE EXTREMELY DIFFICULT IN THE COMING DECADES

PREDICTED ENVIRONMENTAL IMPACTS -- FORESTS AND AGRICULTURE

FORESTS

- WARMING OF 1-3.5 DEGREE C OVER 100 YEARS WOULD BE EQUIVALENT TO A POLEWARD SHIFT OF PRESENT ISOTHERMS BY APPROXIMATELY 150-550 KM (TREE MIGRATION RATES 4-200 KM PER CENTURY)
- NEW ASSEMBLAGES OF SPECIES AND NEW ECOSYSTEMS MAY BE ESTABLISHED
- 1/7 TO 1/3 OF EXISTING FORESTED AREA WILL UNDERGO MAJOR CHANGES IN BROAD VEGETATION TYPES
- FOREST DIEBACK COULD LEAD TO LARGE C RELEASE

AGRICULTURE

- IMPACTS VARY CONSIDERABLY ACROSS REGIONS
- GLOBAL AGRICULTURAL PRODUCTIVITY COULD BE MAINTAINED RELATIVE TO CURRENT LEVELS UNDER $2XCO_2$

PREDICTED ENVIRONMENTAL IMPACTS - COASTAL SYSTEMS

- RISE IN SEA LEVEL OR CHANGES IN STORMS/STORM SURGES COULD RESULT IN:
  - EROSION OF SHORES
  - INCREASED SALINITY OF ESTUARIES AND FRESHWATER AQUIFERS
  - INCREASED COASTAL FLOODING
  - ECOLOGICAL IMPACTS
- 50 CM SEA LEVEL RISE WOULD INCREASE FROM 46 TO 92 MILLION THE NUMBER OF PEOPLE PER YEAR AT RISK OF FLOODING DUE TO STORM SURGES
- ESTIMATED LAND LOSSES AS HIGH AS 80%

PREDICTED ENVIRONMENTAL IMPACTS - HYDROLOGICAL SYSTEMS

- MORE SEVERE FLOODS AND DROUGHTS IN SOME PLACES AND LESS SEVERE IN OTHERS
- CHANGES IN RUNOFF, QUANTITY AND QUALITY OF WATER SUPPLIES

PREDICTED ENVIRONMENTAL IMPACTS - HEALTH

- MOSTLY ADVERSE IMPACTS, WITH SIGNIFICANT LOSS OF LIFE DUE TO:
  - HEAT WAVES
  - VECTOR-BORNE INFECTIOUS DISEASE SUCH AS MALARIA, DENGUE, YELLOW FEVER
  - RESPIRATORY AND ALLERGIC DISORDERS
  - DECLINE IN NUTRITIONAL STATUS
  - LIMITATIONS ON FRESHWATER SUPPLIES
- 3-5 DEGREE C LEAD TO 10% INCREASE MALARIA (50-80 MILLION NEW CASES)
- QUANTIFYING THE POTENTIAL IMPACTS IS DIFFICULT DUE TO VARYING CIRCUMSTANCES SUCH AS NUTRITION, WEALTH, ACCESS TO QUALITY HEALTH SERVICES

IMPACTS - WELFARE

- IMPACTS EXPECTED FOR:
  - ENERGY
  - INDUSTRY
  - TOURISM
  - TRANSPORTATION INFRASTRUCTURE
  - HUMAN SETTLEMENTS
  - INSURANCE
  - CULTURAL SYSTEMS AND VALUES
- AMONG SECTORS AND ACTIVITIES STATED TO BE MOST SENSITIVE ARE:
  - ENERGY DEMAND
  - PRODUCTION OF RENEWABLE ENERGY SUCH AS HYDROELECTRICITY AND BIOMASS

VULNERABILITY

- SOME COMMUNITIES MORE VULNERABLE BECAUSE OF INCREASING POPULATION DENSITY IN SENSITIVE AREAS
- DEVELOPING COUNTRIES, WHERE ECONOMIC AND INSTITUTIONAL CIRCUMSTANCES ARE LESS FAVORABLE, TYPICALLY MORE VULNERABLE
- QUANTITY AND QUALITY OF WATER SUPPLIES IS ALREADY A SERIOUS PROBLEM IN MANY REGIONS
- MANY OF THE WORLD'S POOREST PEOPLE POTENTIALLY MOST AT RISK OF WORSENING AGRICULTURAL SITUATIONS
- FRAGMENTED LANDSCAPES CAN INCREASE THE VULNERABILITY OF LIGHTLY-MANAGED AND UNMANAGED ECOSYSTEMS
- ADAPTATION OPTIONS FOR MANAGED SYSTEMS AVAILABLE BUT LESS SO FOR MANY REGIONS DUE TO HIGH COST OR LIMITED ACCESS TO TECHNOLOGIES AND INFORMATION

CLIMATE EXTREMES -- RECORD TEMPERATURES IN THE 1990'S

- BRITISH -- GLOBAL MEAN TEMPERATURE IN 1995 HIGHEST SINCE RECORDS KEPT IN 1856
- NASA -- 1995 TIED WITH 1990 AS HOTTEST YEAR SINCE 1866
- BRITISH -- 1991-1995 WARMEST 5-YEAR PERIOD, EVEN WITH MT PINATUBO'S COOLING INFLUENCE FROM 1991-94
- SATELLITES -- 1995 AVERAGE COMPARED TO 1982-1991 -- MEASURE ENTIRE LOWER ATMOSPHERE, WHEREAS BRITISH AND NASA RESULTS ARE FOR SURFACE ONLY

CLIMATE EXTREMES -- MORE FREQUENT/VIGOROUS STORMS NOW?

- THE INSURANCE INDUSTRY IS CURRENTLY UNDER STRESS FROM A SERIES OF BILLION DOLLAR STORMS SINCE 1987

- THE IPCC IS CAUTIOUS:

  - "SOME IN THE INSURANCE INDUSTRY PERCEIVE A CURRENT TREND TOWARD INCREASED FREQUENCY AND SEVERITY OF EXTREME CLIMATIC EVENTS. EXAMINATION OF THE METEOROLOGICAL DATA FAILS TO SUPPORT THIS PERCEPTION IN THE CONTEXT OF A LONG-TERM CHANGE, ALTHOUGH A SHIFT WITHIN THE LIMITS OF NATURAL VARIABILITY MAY HAVE OCCURRED."

  - HIGHER LOSSES STRONGLY REFLECT INCREASES IN INFRASTRUCTURE AND ECONOMIC WORTH IN VULNERABLE AREAS

  - ON REGIONAL SCALES THERE IS CLEAR EVIDENCE OF CHANGES IN SOME EXTREMES AND CLIMATE VARIABILITY INDICATORS. SOME CHANGES HAVE BEEN TOWARD GREATER VARIABILITY, SOME HAVE BEEN TOWARD LOWER VARIABILITY

  - TO-DATE IT HAS NOT BEEN POSSIBLE TO FIRMLY ESTABLISH A CLEAR CONNECTION BETWEEN THESE REGIONAL CHANGES AND HUMAN ACTIVITIES

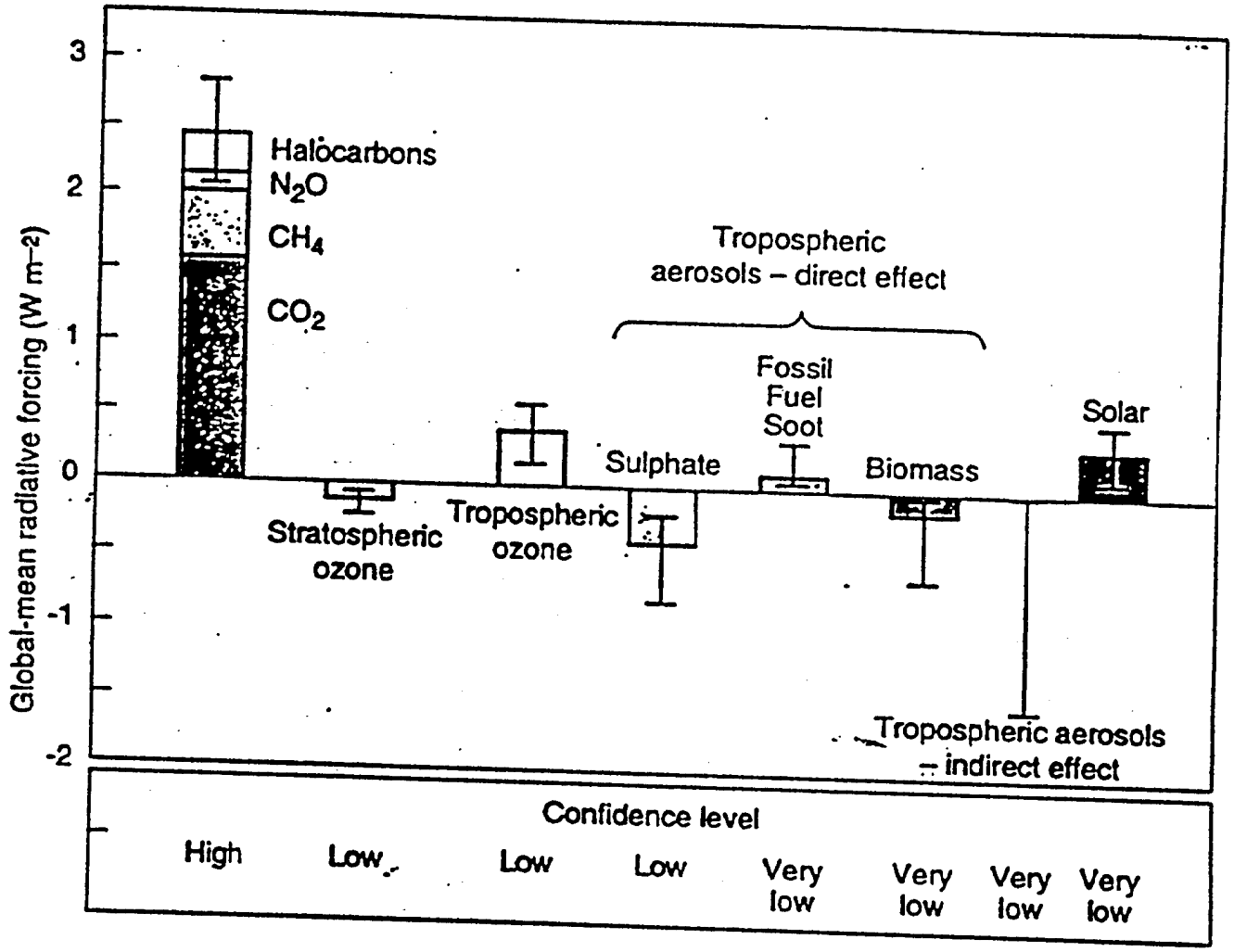
CLIMATE EXTREMES -- MORE FREQUENT/VIGOROUS STORMS NOW?

- REGARDING THE *FUTURE*:
  - PROSPECTS FOR MORE SEVERE FLOODS AND DROUGHTS IN SOME PLACES AND LESS SEVERE IN OTHERS
  - THE RELIABILITY OF REGIONAL-SCALE PREDICTION IS LOW AND THE DEGREE TO WHICH CLIMATE VARIABILITY MAY CHANGE IS UNCERTAIN

OTHER SIGNIFICANT FINDINGS

- SULFATE AEROSOLS FROM SO_2 EMISSIONS DUE TO MAN AND VOLCANOS WORK COUNTER TO GHG
- TROPOSPHERIC OZONE IS IMPORTANT GREENHOUSE GAS BUT NO_X CONTRIBUTION TO IT UNCERTAIN/VARIABLE SO NO_X GWP REMAINS UNDEFINED
- SOME LONG-LIVED GHG -- HFC'S AND SF_6 -- CONTRIBUTE LITTLE TO RADIATIVE FORCING NOW BUT PROJECTED GROWTH COULD LEAD TO SEVERAL PERCENT TO RADIATIVE FORCING
- GROWTH IN CONCENTRATION OF CFC'S SLOWED TO ABOUT ZERO

Global-mean radiative forcing
1850 — 1990



OTHER WORKING GROUP I ISSUES -- STABILIZATION ANALYSES

- IF CO_2 MAINTAINED AT 1994 LEVELS, REACH ABOUT 500 PPM BY 2100 (VERSUS 280 PPM IN 1750 AND 360 PPM NOW)
- TO STABILIZE AT 450 PPM, NEED TO DROP TO 1990 LEVELS IN 40 YEARS AND SUBSTANTIALLY LOWER AFTER THAT
- IPCC NOTES THAT THE INTEGRAL OF EMISSIONS IS KEY - THE EVENTUAL CONCENTRATION IS GOVERNED MORE BY THE ACCUMULATED CO_2 THAN BY THE WAY THOSE EMISSIONS CHANGE OVER THE PERIOD

STABILIZATION ANALYSES

TOM WIGLEY (NCAR), RICH RICHELS (EPRI) AND JAE EDMONDS (BATTELLE) ARTICLE IN NATURE ENTITLED "ECONOMIC AND ENVIRONMENTAL CHOICES IN THE STABILIZATION OF ATMOSPHERIC CO_2 CONCENTRATIONS"

- MANY DIFFERENT PATHWAYS FOR REDUCING EMISSIONS
- IF ALLOWED TO EMIT "X" TONS, BEST ECONOMICALLY TO EMIT AT A HIGHER LEVEL EARLIER FOR SEVERAL REASONS, INCLUDING:
  - STOCK FOR ENERGY PRODUCTION AND USE IS TYPICALLY LONG-LIVED AND MAKING UNANTICIPATED CHANGES IS VERY COSTLY
  - IMPROVEMENTS IN THE EFFICIENCY OF ENERGY SUPPLY, TRANSFORMATION AND END-USE WILL RESULT IN LESS COSTLY REDUCTIONS
- NOT "DO NOTHING" OR "WAIT AND SEE" -- REQUIRES SUBSTANTIAL RD&D
- MINOR ENVIRONMENTAL IMPACT -- 0.2 DEGREE C GLOBAL MEAN TEMPERATURE INCREASE AND 4 CM SEA LEVEL RISE
- DOE/EPRI WORK INDICATES UP TO 80% COST REDUCTION BY THE COMBINATION OF ALLOWING EMISSION REDUCTIONS ON A PACE WITH NORMAL INVESTMENTS TO REPLACE INFRASTRUCTURE AND EQUIPMENT, PLUS JOINT IMPLEMENTATION

OTHER WORKING GROUP II ISSUES

- MITIGATION OPTIONS
- ADAPTATION OPTIONS

WORKING GROUP III REPORT

- EQUITY AND DISCOUNTING
- COST-BENEFIT ANALYSIS
- SOCIAL COSTS OF CLIMATE CHANGE
- ASSESSMENT OF RESPONSE OPTIONS
- COSTS OF MITIGATING GREENHOUSE GASES
- INTEGRATED ASSESSMENT

HOW TO OBTAIN THE IPCC REPORTS

- TARGET PUBLICATION DATE -- LATE MAY 1996
- COST -- ABOUT $90 IF PURCHASE 3 VOLUMES IN PAPERBACK BY MARCH 31, 1996