Essays on Global Climate Change

STATE *of the* CLIMATE REPORT

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A WORLD IN PERSPECTIVE

STATE *of the* CLIMATE REPORT

Essays on Global Climate Change

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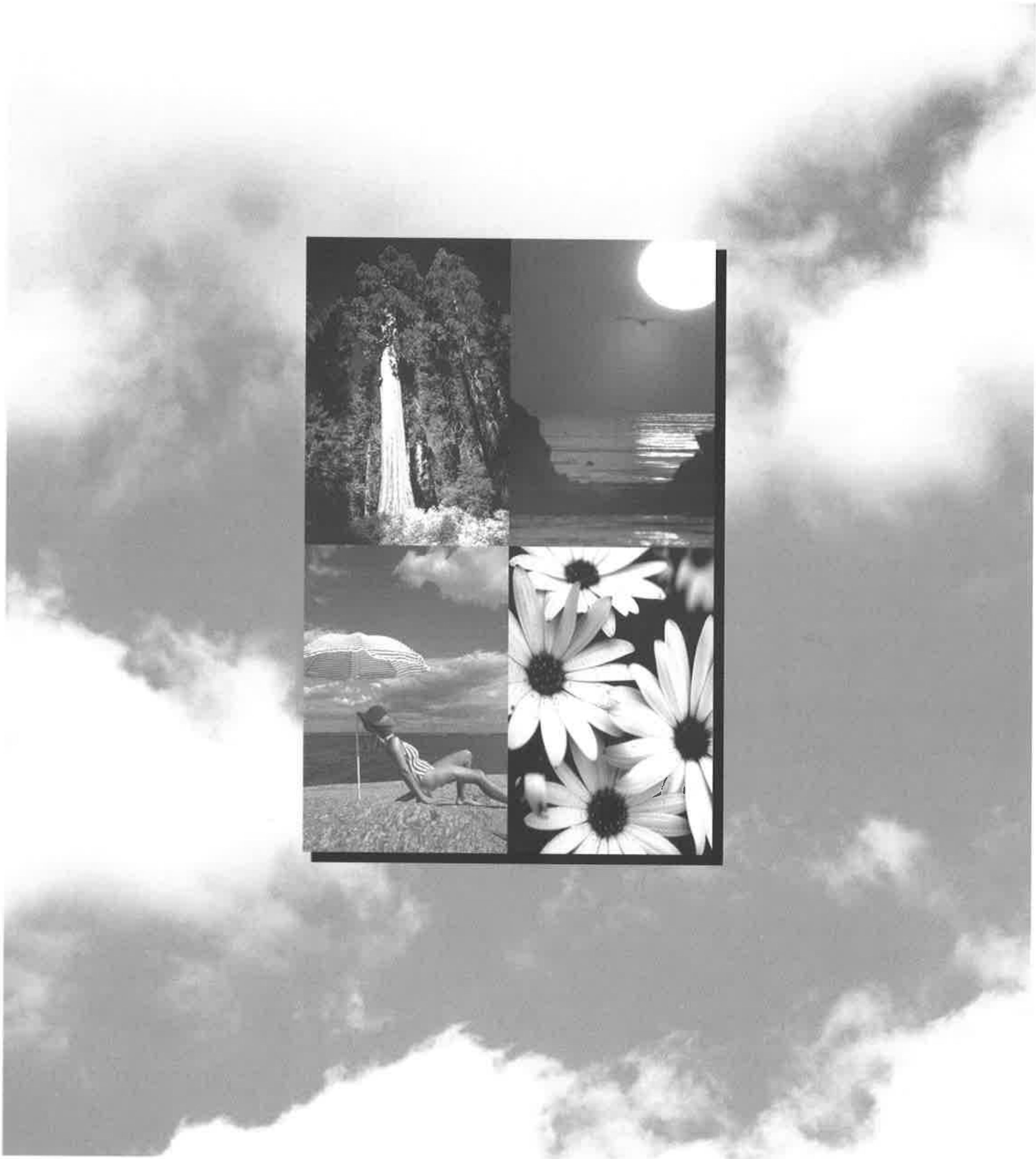


Foreword

A YEAR *of* CLIMATIC HYPERVENTILATION

BY PATRICK J. MICHAELS, PH.D.

Patrick J. Michaels *is a professor of environmental sciences at the University of Virginia. Dr. Michaels is also a senior fellow at the Cato Institute and a visiting scientist at the George C. Marshall Institute, both in Washington, D.C. He is the author of more than 250 scientific and popular articles on climate change and its impact on the ecosystem, and is chief editor of* World Climate Report, *a biweekly newsletter cited internationally as among the world's most influential publications in the global warming debate. According to* Nature *magazine, Dr. Michaels is one of the nation's most sought-after speakers on the subject of global climate change.*

1998. As El Niño's heat escaped out to space, creating an historical spike in all three of our temperature records, so did the heat emanate from the climate doom-and-gloom machine. It seemed every weather anomaly was related to El Niño, and every El Niño to global warming. Fires in Florida? Tornadoes near Disney World? Rainy night in Georgia? Low cotton? Each of these events, breathlessly reported on television, was blamed on climate change. The landmark vignette for 1998 may have been in midsummer, when a major network aired footage ostensibly showing a corn disaster in Texas. The stalks were brown, as is common at harvest time. A combine, or harvesting machine, stirred the dust into a frenzy. Nice footage. If only everyone had just taken a deep breath and calmed down, they would have noticed the large, plump appendages hanging upside-down from the stalks—big ears of corn, about to be plucked, even as the voiceover rambled on about disaster. Helping the world to catch its breath and take a closer look at climate change is what this year's *State of the Climate Report* is all about.

University of Virginia's Robert Davis shows us that the warmer it is, the less the weather varies. Craig Idso, president of the Center for the Study of Carbon Dioxide and Global Change, gives us an A-to-Z list of some of the benefits of increased CO_2. Stanford's Thomas Gale Moore may put a smile on your face as he reminds us that people live longer when it's warm, and they seem happier.

As for the temperature observations, they speak for themselves, with the help of NASA satellite expert Roy Spencer. And we gain some perspective in an interview with Reid Bryson, the University of Wisconsin professor who, 30 years ago, pioneered the research demonstrating that climate can and will change in ways that affect society—whether or not humans do anything to the atmosphere.

As Bryson says, the only thing that is consistent about climate is change.

TEMPERATURES *UNUSUAL*

BUSINESS *as* USUAL

HOT YEAR TESTS GREENHOUSE FEARS

BY PATRICK J. MICHAELS, PH.D.

What a wonderful year! Global temperatures reached their highest value recorded in all three available records—surface, satellite, and weather balloon. Sayers of doom had pronounced dire and immediate consequences—so for once it was possible to check their models of misery against what actually happened when it really got warm. The result? The greenness of the cover of this *State of the Climate Report* is a big hint.

EL NIÑO VS. GREENHOUSE WARMING

Judging from the conflation of El Niño and human-induced global warming, you might think the two were one and the same, or maybe even, as Vice President Al Gore intimated, that one caused the other.

Like many of his reaches, there was a bit of truth in the stretch, but only a bit. Global warming didn't cause El Niño in any appreciable sense, but the two were related: It was a very good El Niño year, and it was a very, very warm year.

El Niño is natural. Just because scientists discover something, or because we, as taxpayers, shell out tens of millions of dollars to research something, does *not* mean that something new has happened. Chemicals existed before chemists, DNA existed before its discovery won a Nobel Prize, and El Niño ebbed and flowed long before the first climatologist was born.

El Niño is a commonly occurring slowing (or even reversal) of the northeasterly and southeasterly trade winds that dominate the tropical Pacific Ocean (Figure 1). When the trades are blowing, they move vast amounts of oceanic water northwestward and then westward from the coast of South America. In doing so they drag the warm water off the surface, and much colder water "upwells" in replacement. So the eastern equatorial Pacific Ocean is relatively cool for a tropical ocean.

No one knows why the trades suddenly slow or even reverse, piling warm water up against South America. Reid Bryson, the modern founder of the very true notion that climate does change in ways that are important to people, believes this reversal is mainly an effect of some other large-scale physical fluctuation. During an El Niño, a large portion of the tropical Pacific is much warmer than average—as much as 8°C (14.4°F)—and this heat eventually disperses through the atmosphere.

Heat is energy, and an El Niño shows up both as warming and as motion. Its reach extends into the tropical Atlantic, where it suppresses—yes, *suppresses*—hurricanes. Rain, often absent for years, falls in the ultradeserts of Peru and Argentina. And the global temperature warms.

When the trade winds return, the cold upwelling reappears. This is La Niña. It stands to reason that the more the cold water is suppressed, the greater the amount that eventually bubbles up, so a big El Niño warm spike may mean a big temperature fall in the months thereafter.

As our daily satellite data show (Figure 2), the lower atmospheric temperature peaked around April, and was in rapid decline through the rest of the year. As of this writing (mid-March 1999) it continues to head south faster than an Internet stock with a bad earnings report.

We're totally confident that 1998's big warming spike was a result of El Niño, and not dreaded "global warming"—that is, a human product. We know because the stratosphere tells us so.

The human version of global warming is caused by increasing amounts of "greenhouse" gases in the lower atmosphere. These compounds absorb the heating radiation that results from the sun's warming of the earth's surface, and re-emit that radiation either downward, resulting in additional atmospheric warming, or out to space. If these compounds weren't there, the radiation would pass directly outward.

Increasing the greenhouse effect, then, warms the lower atmosphere but, by virtue of the "recycling" of warming radiation in the lower atmosphere, cools the stratosphere that lies above. The heat from El Niño, on the other hand, burbles up through it all.

So what we should see from the increasing greenhouse effect is a lowering trend for stratospheric temperature. And El Niño should temporarily stop that trend, at least for a year or so. Figure 3 shows that 1998 was indeed one of the warmest years in the stratosphere in the last two decades and is testimony to El Niño as the cause.

Greenorama

We were besieged with news reports about how El Niño (and, by not-so-subtle extension, global warming) would cause terrible agricultural disasters. Who can forget the miles of CNN footage showing tractors mired in the Georgia mud, or network reels of browned corn in Texas?

Well, some folks did poorly, and some folks did well. That happens every year. About the best way we know of to settle the overall score is in the wheat, corn, and soybean markets. When there's a big supply, the price goes down. Demand fluctuates some too, but a perpetually increasing population has a way of ensuring more mouths to feed.

By late 1998, the price of U.S. wheat stood, after adjusting for inflation, at its lowest level since reliable records began in 1915. Fluctuations in America's massive supply of agricultural products, more than anything, dictate the global price.

Turns out all that rain in the winter—so ugly on television—was quite salutary for the major food and feed crops, especially wheat. Figure 4 shows the U.S. historical wheat yields, and there's little doubt that 1998 gets the prize.

Many agricultural economists and a few climatologists have made careers of studying the influence of global weather patterns on crop yields. Moisture at planting time and in the

Figure 1.

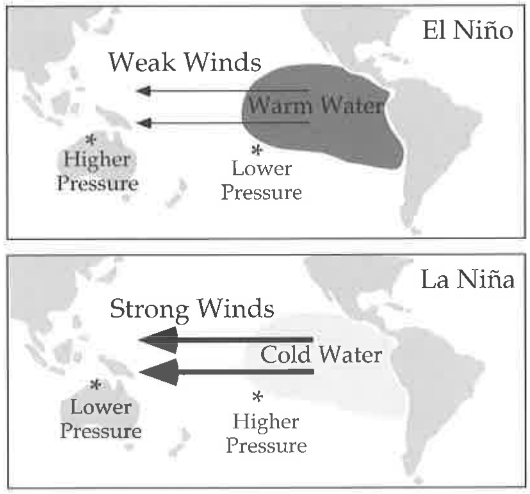


Figure 1. Schematic representation of the conditions that occur during an El Niño event as compared with a La Niña event.

Figure 2.

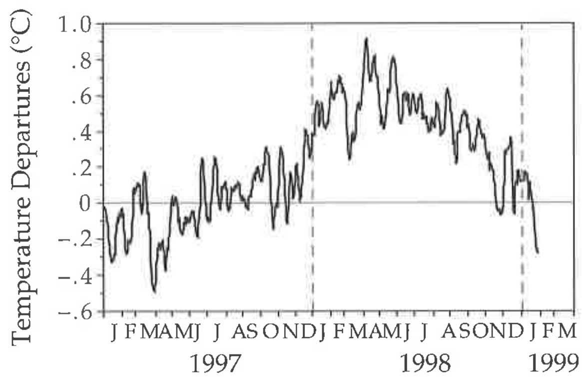


Figure 2. Daily measurements of the global temperature anomalies as observed by satellites show that the anomalies peaked in the month of April 1998 and have been declining ever since.

Figure 3.

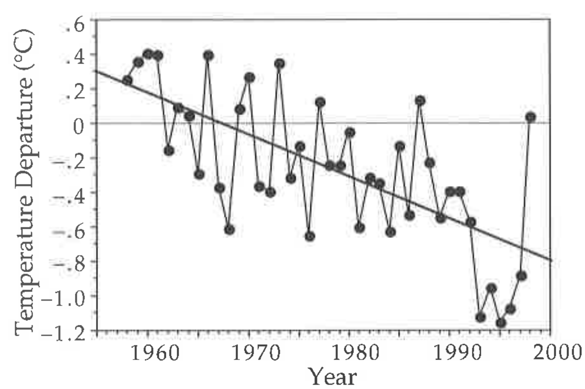


Figure 3. The rather steady decline in stratospheric temperatures was abruptly interrupted in 1998—a strong sign of El Niño.

Figure 4. Historical yields of wheat in the United States (inset: since 1970). The El Niño year of 1998 holds the record. Notice that yields were also very high during the last great El Niño year, 1983.

Figure 4.

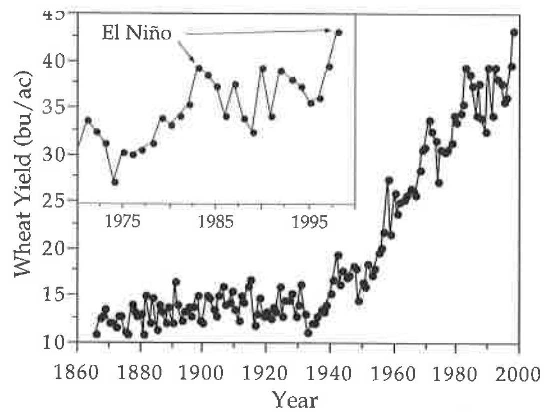
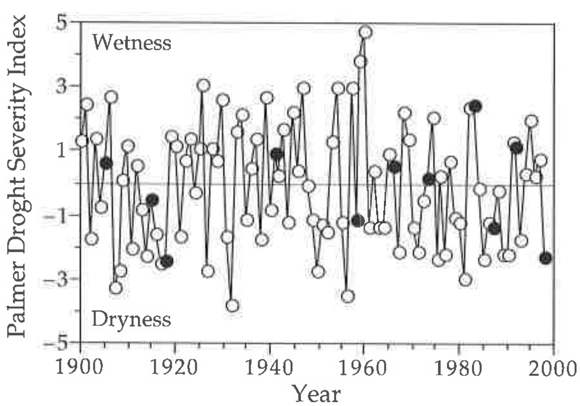


Figure 5. The history of the Palmer Drought Severity Index for central Florida during summer. The filled circles indicate those years with a strong El Niño in the preceding winter. There is no relation between El Niño and summer droughts in Florida.

Figure 5.



winter before harvest is the major determinant—by far—of winter wheat yield. Winter wheat is planted in the early fall, requires moisture to germinate, and then, when spring springs, is really poised to take advantage of wet soil. In addition, yields are positively influenced by above-normal winter temperatures.

Undoubtedly, the climate of 1998 led to the record yields. But there was another factor as well: Increased carbon dioxide in the air increases yields and makes crops much more efficient in their use of moisture. As Sylvan Wittwer, former head of the Board on Agriculture of the U.S. National Research Council wrote, "Overall, it has been conservatively estimated that global crop productivity has risen by approximately 2.5 to 10 percent, and possibly as high as 14 percent from the current increase in atmospheric CO2 over pre-industrial levels."

WE'VE SEEN FIRE AND WE'VE SEEN RAIN

Two other prominent newsmakers this year included the spate of overland fires in Florida during the early summer, and Mitch, a real son-of-a-gun of a flood, but really not much of a hurricane by the time it hit land.

We were tempted to say, "Now there you go again, Al," about Florida, when he said the fires offered a "glimpse of what global warming may mean to families across America." In fact, the natural Florida ecosystem (something pretty hard to find with all the Disney Worlds, Homosassa Springs and Kissimmees dotting the landscape) is attuned to fire. Judging from their writings, the early Florida explorers found the burning of the peninsula perhaps its most impressive aspect.

That didn't stop everyone from blaming all this on El Niño and global warming, but the fact is that, in general, there is no relationship between summer dryness in Florida and the existence of an El Niño during the previous winter. That's because El Niño makes it rain during the winter greening season. In the summer, there's precious little documentation that El Niño does anything at all to Florida weather. Of course, we could blame Florida's high temperatures this year on global warming, but that would mean ignoring the fact that changing the greenhouse effect warms up the coldest air masses a lot more than it heats up the warmer tropical ones.

Hurricane Mitch was a tragedy, but unfortunately, not a singularity. Mitch started as a Category 5 (that's the worst kind) hurricane in the western Caribbean. These are not all that uncommon in that part of the world. Edith (1971) and Janet (1955), for example, come to mind (Figure 6). Because it was a slow mover, as Mitch interacted with the mountains of Central America, the winds dropped to Category 2 status, but the rains were extreme. Precipitation totals of more than 50 inches brought tremendous flooding and loss of life. Although the actual number of deaths remains quite elusive, it was clearly in the ten-thousand range. Speaking in Argentina at a meeting designed to strengthen the United Nations climate treaty, State Department Spokesman J. Brian Atwood told U.S. networks that Mitch was a "typical greenhouse effect."

That was inflammatory nonsense. A 1974 hurricane named Fifi, which was also a Category 2 at landfall, took much the same track and killed 7,500. Janet and Edith had much more powerful winds and wreaked tremendous havoc. Perhaps the most interesting comparative aspect with Mitch is that a tropical storm named Claudette, in 1979, also produced 50 inches of rain and resulted in nine deaths (that's about 9,990 fewer than Mitch caused) when it hit Texas. Perhaps infrastructure and poverty, not global warming, created the tragedy named Mitch. Maybe, just maybe, allowing us to save our money for investment in developing nations like Honduras and El Salvador is a better idea than taking it away in an attempt to stop something that would happen anyway.

El Niño and hurricanes do share at least one common trait. They have been around for a long time and the biota of the world, thanks to the nature of evolution, likely take advantage of them. In California, rains of the magnitude that associate with El Niño are required to make the desert bloom. Just any old storm isn't enough, even though the ground gets wet. In that environment, many seeds have to be scarred by the motion of overland movement of water before they'll even germinate.

Long before banging the climate-disaster gong became the key to career advancement, federal climatologist George Cry calculated the percentage of normal rainfall that comes from all tropical cyclones, including tropical depressions, storms, and hurricanes in the eastern United States. Figure 7 shows the result for September.

In most of the areas with high values, American agriculture has adopted a double-crop system that plants one early, fast-maturing crop, and then replaces it with an October harvest crop, mainly soybeans. Late August and September rain can be very important determinants of final yield. It's pretty clear that years in which amounts are below normal because of lack of tropical cyclones are those in which yields are in jeopardy.

People adapt to their climatic environment. The biota of the world take advantage of change, and so does our agriculture: One of the biggest El Niños in recent centuries produced a glut of food. That's the lesson of 1998.

But the climate hype of 1998 also has portents. If this past year is any guide, when global warming becomes a major focus of the Y2K presidential campaign, the amount of distortion, exaggeration, scare stories and fear-mongering we're sure to witness will be a real climate disaster. ▲

Figure 6.

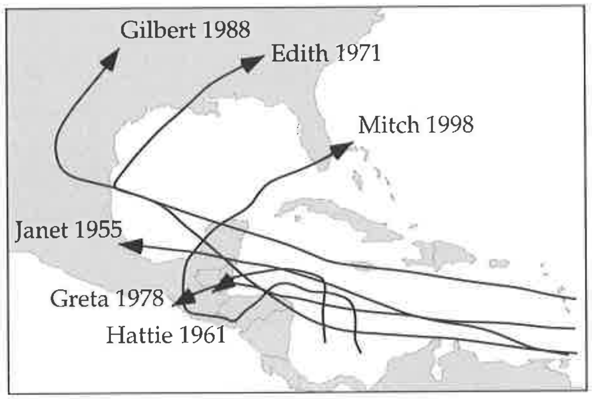


Figure 6. Six Category 4 or 5 hurricanes have occurred in the same vicinity as Mitch since 1950. That's about one every eight years.

Figure 7.

Figure 7. The percentage of September rainfall in the eastern United States that comes from tropical systems. The regions that normally receive more than 15 percent are shaded.

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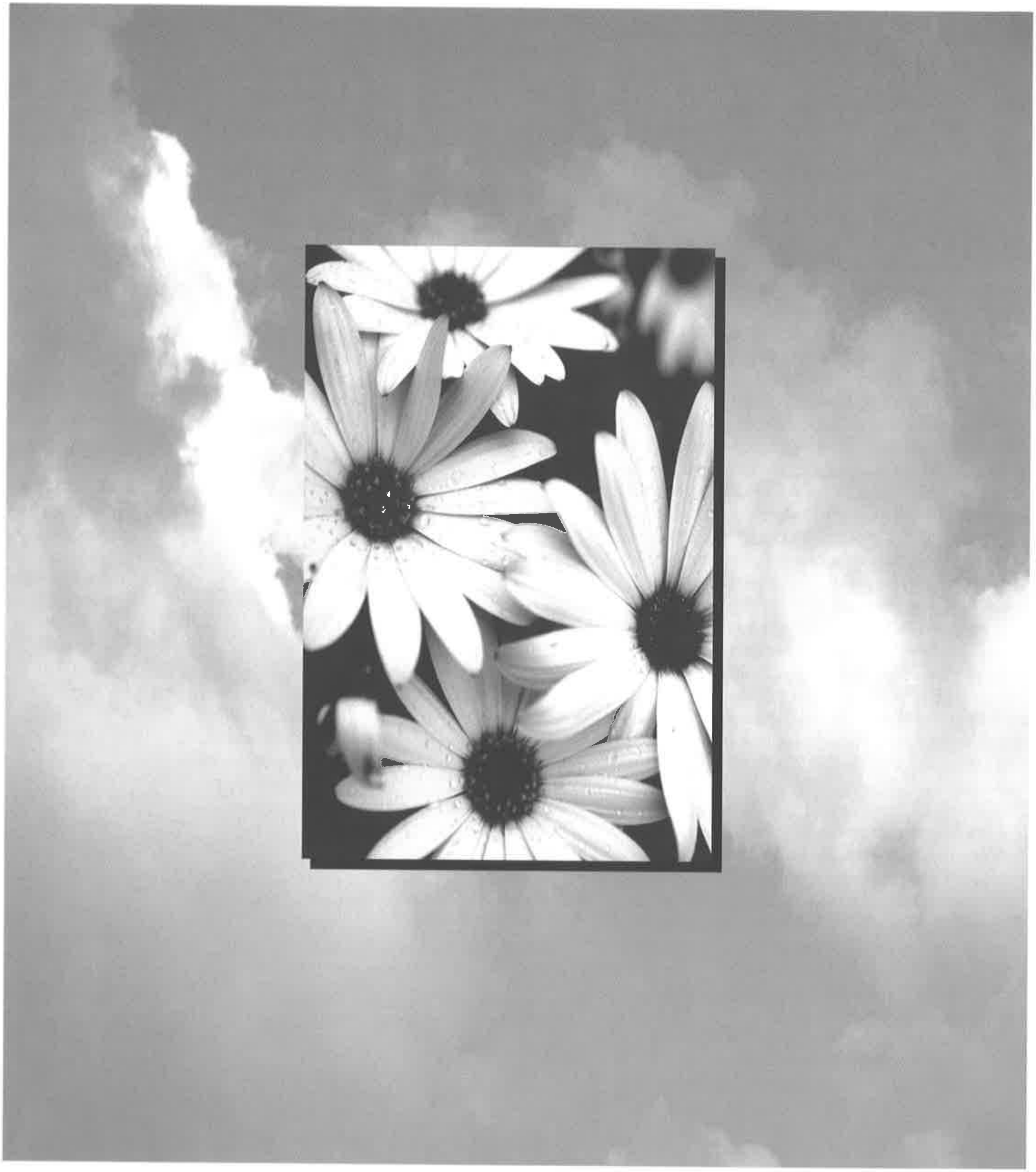

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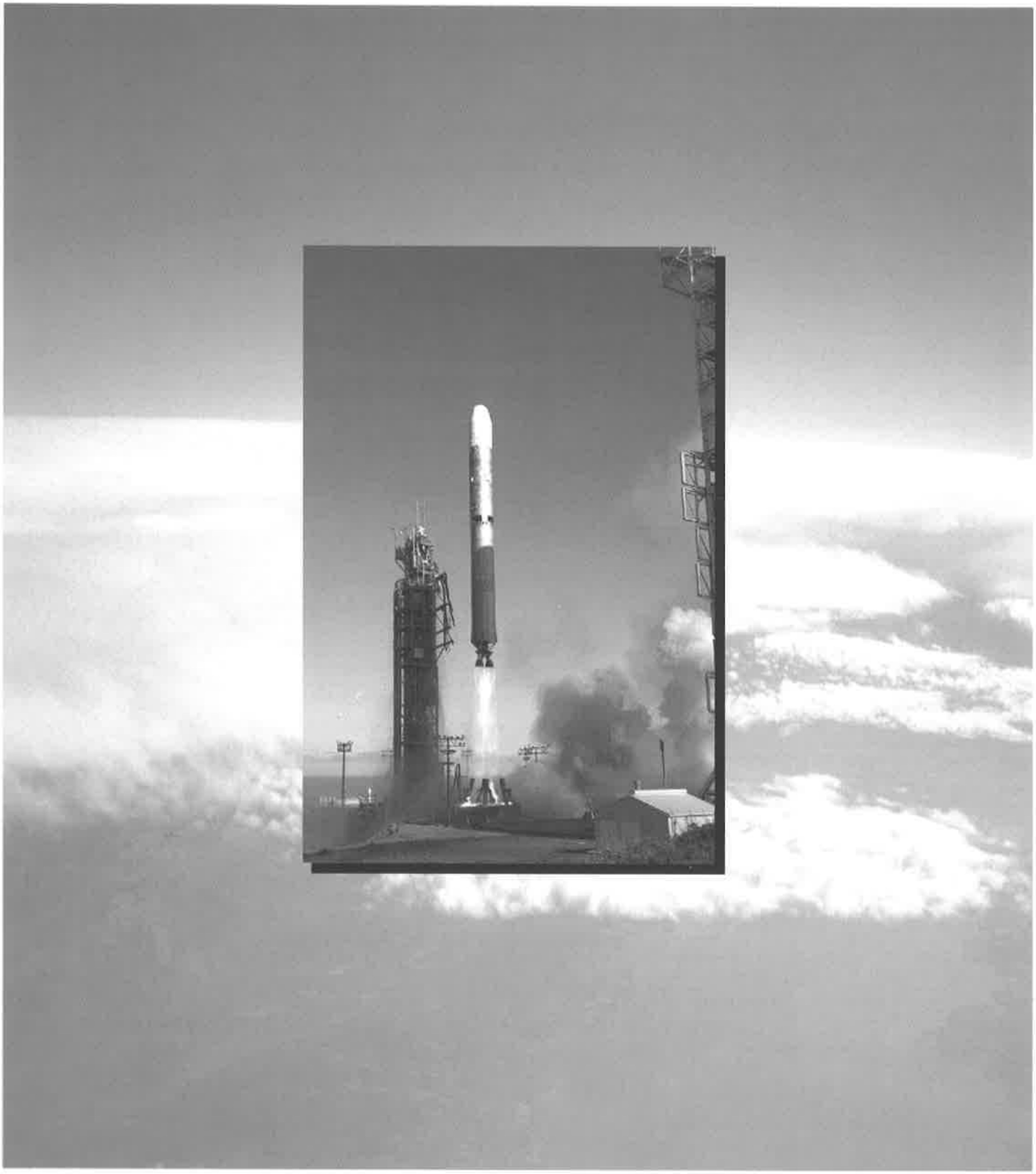


TEMPERATURES *from* SPACE

1998's WARMTH BEARS THE MARK OF EL NINO

BY ROY W. SPENCER, PH.D.

Roy W. Spencer is Senior Scientist for Climate Studies at NASA's Marshall Space Flight Center in Huntsville, Ala., where he directs research on developing and applying passive microwave remote sensing techniques from satellites for measuring global temperature, water vapor, and precipitation. In 1996, the American Meteorological Society honored him with a Special Award for his satellite-based temperature monitoring work. He also received NASA's Exceptional Scientific Achievement Medal. He is the U.S. Team Leader for the Advanced Microwave Scanning Radiometer to be flown on NASA's PM-1 satellite in 2000. Both the House and the Senate have invited him to testify on the subject of global warming. Dr. Spencer earned his Ph.D. in meteorology from the University of Wisconsin in 1981.

Following the surface thermometer record's lead, the satellite global temperature record reached its own historical high in 1998. As the most recent El Niño waned, the excess heat that built up at the sea surface in the tropics during 1997 was transferred at an accelerated rate to the deep troposphere, where satellites make temperature measurements by observing fluctuations in the amount of microwave radiation oxygen molecules emit. The satellites observed the peak temperature in early 1998 and saw it slowly decrease to near-normal values by the end of the year (Figure 1). The average long-term trend for the period 1979–1998 now stands at +0.05°C per decade, which is about one-fourth of what the global warming theory of the United Nations Intergovernmental Panel on Climate Change (IPCC) predicts for the next 100 years. The long-term trend is also in conflict with the surface thermometer record, which suggests a warming of closer to +0.20°C per decade for the same period of time.

This difference between the surface and satellite temperature trends continues to be one of the most important unsolved questions in the field of climate change. Much research is currently under way to try to obtain a better understanding of this discrepancy. As it stands, it points to a gap in our understanding of the climate dynamics of the lower atmosphere and its interactions with the surface.

Until we close that gap, we cannot rely on climate models to give us an accurate picture of what is to come.

Figure 1a. Monthly satellite-measured temperature departures for the globe, since observations began in 1979. The departures are relative to the 1979–1998 mean. The trend over the course of this record is 0.05°C per decade.

Figure 1a.

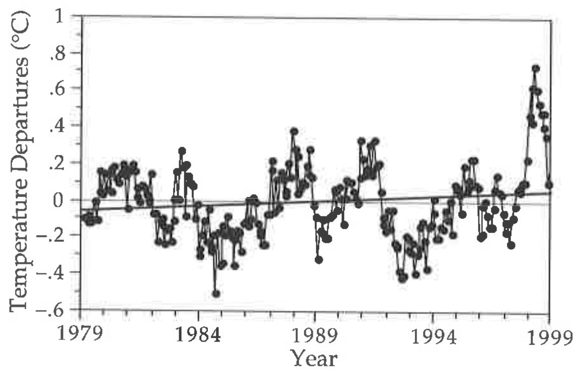


Figure 1b. Monthly satellite-measured temperature departures for the Northern Hemisphere. The trend over the course of this record is 0.11°C per decade.

Figure 1b.

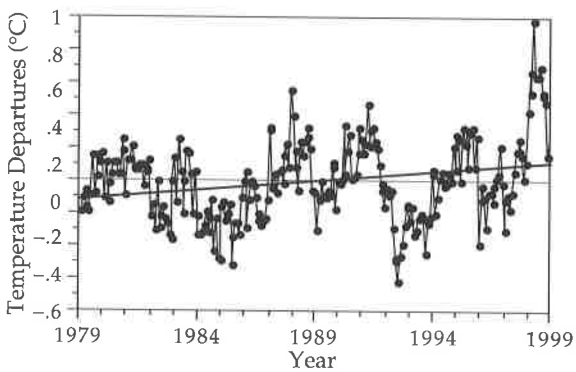
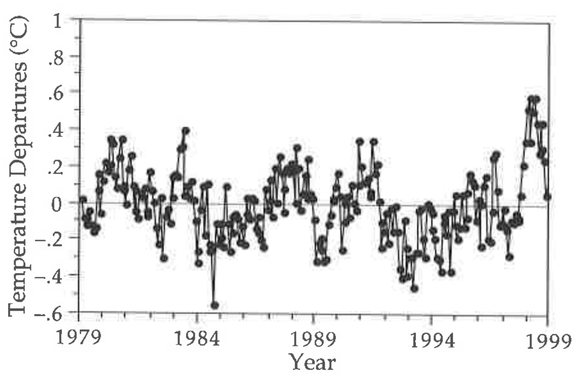


Figure 1c. Monthly satellite-measured temperature departures for the Southern Hemisphere. There is no trend over the course of this record.

Figure 1c.



The 1997–1998 El Niño was a major climate event, and its effect on temperature was evident in both the surface and the satellite measurements. It was unusual both in its strength and in that there was no major volcanic eruption to mask its warming influence. Indeed, the past coincidence between volcanic eruptions and El Niño was so frequent that at least one climate researcher has been advocating the position that volcanoes cause El Niños to occur. But this theory has not been very popular in the research community.

Figure 2 shows the global distribution of 1998 temperature anomalies, revealing that, as expected for an El Niño, most of the warmth was found in the tropics.

Other warm areas in Figure 2 are located over most of North America and Greenland, with a large area averaging more than 1°C above normal for the year, and in northern Canada nearly 2°C above normal. The West Coast of the United States was slightly below normal.

Still other warm areas included much of southern Europe through the Middle East and southern Asia, where one-half to one degree anomalies were common. Cooler-than-normal conditions dominated northern Europe through much of Russia. The cold Russian weather set records across that nation. Late fall and early winter there (September through November) were especially cold in the satellite data, with most of Russia being covered by 2°C to 4°C below normal tropospheric temperatures during the month of November.

What's It All Mean?

What does a record warm year in 1998 mean in the context of global warming theory? First, El Niño, a naturally occurring phenomenon, is what made 1998 a record year. This does not, however, preclude the possibility that some of that warmth was contributed to by global warming.

Second, any given year (or even 20-year period) cannot be interpreted in the context of global warming with much confidence since the predicted warming is only 0.2°C per decade. If the true amount of warming is only 50 percent of that prediction, a view that I support, then the warming amounts to only 0.01°C per year (!). Given that the earth's temperature goes through natural fluctuations of up to 1°C per year, you can appreciate how difficult it is to identify global warming without many decades of data. This is why scientists rely so much upon the last 100 years of the thermometer data when they search for signs that the globe is heating up.

Continued Controversy

On the subject of the satellite vs. surface temperature trends, the controversy continues. The National Research Council has formed a panel to address those differences and what they mean. The first meeting of experts on the satellite, surface, and radiosonde measurements was held in Asheville, N.C., during the week of March 8, 1999. The consensus of opinion of that panel, so far, is that some portion of the disagreement is likely real, but there are remaining uncertainties about the calibration of the satellite data. That the radiosonde record shows even less warming than the satellite (or cooling, for that matter) in the last 20 years is especially confounding.

Another event of importance in 1998 was the launch of the first Advanced Microwave Sounding Unit (AMSU) on the NOAA-15 satellite. This first copy of the successor to the Microwave Sounding Units (MSU) has been operating very well, and is providing much more data than we have ever had before. The AMSU can measure the temperature of 11 layers (instead of three from the MSU, two of which were useful). These layers extend from near the surface to the upper stratosphere. The design of AMSU is much newer, with better and more accurate calibrations. Its creators hope that this new source of high-quality data will lead to wider acceptance of the satellite temperature record in the future. ▲

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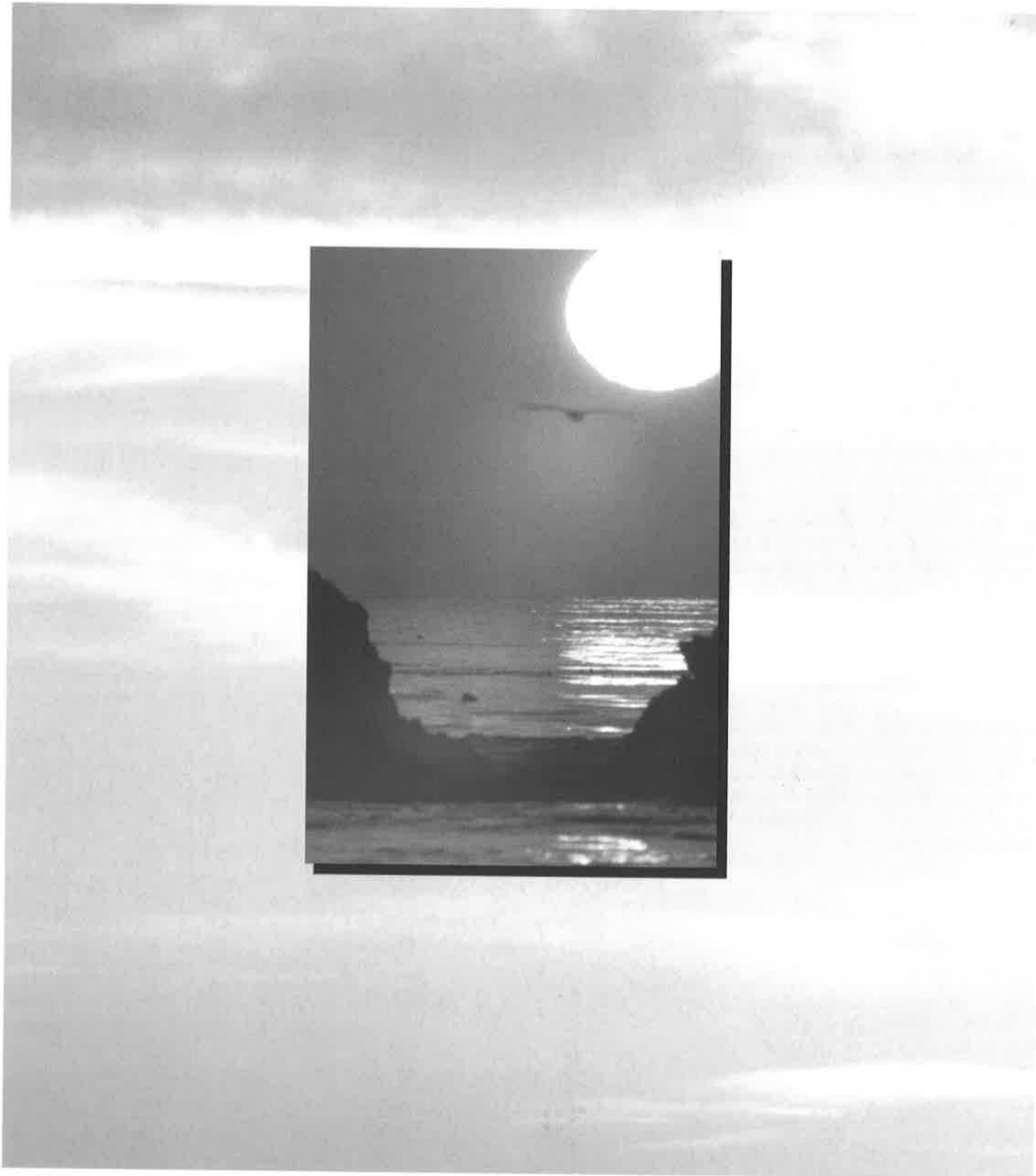
Figure 2a.

Figure 2a. Annual temperature departures (°C) across the Western Hemisphere during 1998. Most of the area experienced above-normal temperatures, with the exception of the southern polar regions and a small portion of the U.S. West Coast. Shaded regions are below normal.

Figure 2b.

Figure 2b. Annual temperature departures (°C) across the Eastern Hemisphere during 1998. Most of region experienced above-normal temperatures, with the exception of the southern polar regions and portions of northern Asia.



GOING *to* EXTREMES

MEDIA COVERAGE OF 1998's NOT-SO-UNUSUAL WEATHER EVENTS

BY ROBERT E. DAVIS, PH.D.

Robert E. Davis *is associate professor of climatology at the University of Virginia. His primary interests are large-scale climatology, applied climatology, and climate change. Dr. Davis has written numerous general and technical papers on topics such as atmospheric circulation change, Atlantic coastal storms (nor'easters), air quality, and the relationships between weather and morbidity and mortality. A contributor to the 1995 IPCC report, he has testified on global climate change before the House Science Committee. He has served on government panels relating to global change and data quality issues with the EPA and NOAA. Dr. Davis received his B.S. in meteorology from Pennsylvania State University in 1982; he earned an M.S. and Ph.D. in climatology from the University of Delaware in 1988.*

To practitioners who hold to the philosophy of global warming above the science, 1998 was a blessed year. Based on surface temperatures, it was *the* warmest year on record. It had one of the largest El Niño events in history. Killer droughts hit some areas, resulting in torrential fires that destroyed pristine wilderness. Ravaging flood waters submerged peaceful villagers in watery graves. Savage hurricanes decimated defenseless inhabitants who were ill-prepared to escape the storms' wrath. As our planet continues to warm because of humans' industrialization and modernization, should we expect more years of record warmth, aberrant storms, and wild weather fluctuations? Is this a glimpse into our future? This is the common belief.

The science is another matter entirely.

All of these weather events actually happened in 1998, and most have likewise occurred in every calendar year since the dawn of humankind. The exception, of course, are the record temperatures and the strong El Niño—forever in the annals of climate history, in any discussion of the year of our Lord one thousand nine hundred and ninety-eight, the two will be inextricably linked.

The El Niño that dominated 1998's climate actually began in early 1997 (Figure 1). While many experts interpreted the rapid downturn in September 1997 as the beginning of the end for this El Niño, it hung around and actually intensified again in early 1998, producing an unusually long, double-peaked El Niño event.

The last mother-of-all-El Niños was in 1982–1983. Although global temperatures were high that year, they have been easily surpassed many times since then. The reason? Not global warming, but volcanoes. The El Chichon volcano erupted in 1982. Because volcanic dust and ash reflect away incoming solar radiation, global temperatures are significantly suppressed after major eruptions. Using an algorithm developed by satellite temperature specialist Roy Spencer, the volcanic effect was removed from the global satellite temperature

Figure 1.

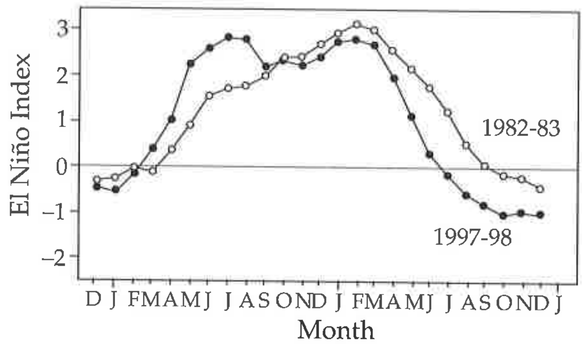


Figure 1. The temporal evolution of the 1982–1983 (open circles) and the 1997–1998 El Niño events (closed circles).

Figure 2a.

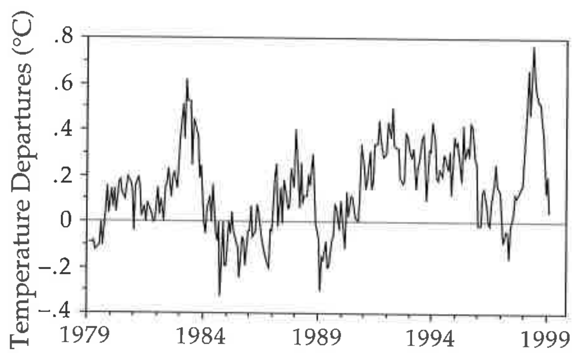


Figure 2a. Satellite-measured temperature departures (°C) after the influence of volcanoes has been removed.

Figure 2b.

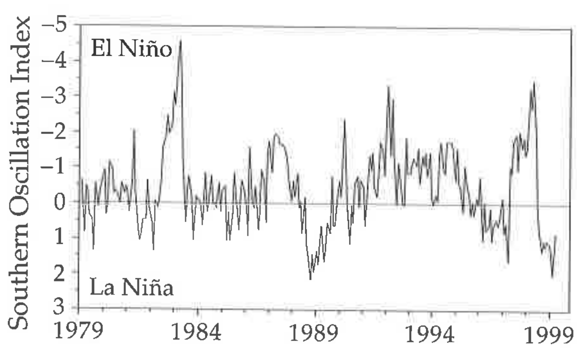


Figure 2b. Monthly Southern Oscillation Index (SOI) values. The SOI has been inverted to better correspond to the satellite temperatures in Figure 2a.

record and then the adjusted temperatures were compared with the Southern Oscillation Index (SOI), a common measure of the status of El Niño (Figure 2). All of the major warm periods correspond with negative values of the SOI (or El Niño conditions). In fact, the 1998 satellite temperature departures are comparable to the 1982–1983 values after accounting for the volcanic contribution.

El Niño garnered extensive coverage from the media, marking the first time in history that a climatic event truly captured the imagination of the public. Everyone everywhere seemed to be talking about El Niño. On the flip side, despite a decade-long media deluge, no one seemed to care about global warming. In a 1997 poll of environmental issues, global warming ranked eighth behind such concerns as pollution of air and waterways, loss of rain forests, and damage to the ozone layer. To an administration whose environmental agenda is built upon the threat of global warming, this was completely unacceptable.

So 1998 will be remembered as the year in which El Niño was conflated with global warming. Vice President Al Gore, after finding a federally funded scientist or two to back him up, hit the media preaching that if you think this year is bad, wait about 10 or 15 years when global warming gets worse—because global warming will produce a climate just like the one this El Niño did. Furthermore, El Niños will become more common or maybe even stronger when coupled with global warming. And this is the worst El Niño in history.

Of course, that's all nonsense. El Niños are as regular as prunes. And some believe they're actually occurring a little less often. A 1998 study, based on data reconstructed from tropical and subtropical tree rings, shows that La Niñas (the climatic opposite of El Niños) have actually been much more common over the past 100 years (Figure 3). Furthermore, the record warmth of 1998 was driven by tropical temperatures. According to a year-end report by the National Oceanic and Atmospheric Administration, the tropics (which they define as the area between 30 degrees north and south of the equator) were a record 1°C above the long-term mean. Greenhouse warming should be concentrated in the high latitudes in winter.

In the United States, the impact of the 1998 El Niño was unquestionably positive. If it was indeed responsible for the elevated 1997–1998 winter temperatures, then we realized significant savings on snow removal and heating costs. From the Northeast to the Great Lakes, the January-through-May period was the warmest on record. Estimates of the national savings in energy costs alone (based on historical data from the Department of Energy's *Annual Energy Review*) exceeded $5 billion.

So the record heat of 1998 appears to be largely El Niño–driven. By midsummer, the prolonged El Niño had finally slackened off, even though temperatures remained high through November. This was not surprising, however, since there is a several-month lag between the start of El Niño and the beginning of high temperatures in the satellite record. Finally in December, temperatures plummeted, perhaps as a harbinger of 1999, when global temperatures will likely return to more typical, non–El Niño-like norms.

Hard Data

Needless to say, the media hype that accompanied 1998's weather was far more exceptional than the actual events. The press coverage was replete with stories about the incredibly wild fluctuations observed worldwide throughout the year. These proclamations were made without supporting data, of course. But is the climate in fact more extreme in warm years than in cold?

This question was addressed in several different ways by Arizona State professor Robert Balling Jr. and colleagues. Using well-established gridded global archives of temperature, they examined the relationships between month-to-month variability and average temperature. And they uncovered a very clear, statistically significant signal (Figure 4). This finding convincingly demonstrates that warm years have less monthly temperature variability than cold years. The 50-year trend (not shown) also has a significant decline in variability that corresponds to the rising temperatures during this period.

In a related study, Balling examined the variability of temperature from place to place. Using monthly gridded temperature anomalies, this time from the Northern Hemisphere, he calculated the "spatial variance" then summarized the data for each year and compared these values to hemispheric average temperatures. Once again, there is a negative (though weaker) relationship between these data (Figure 5). In

Figure 3.

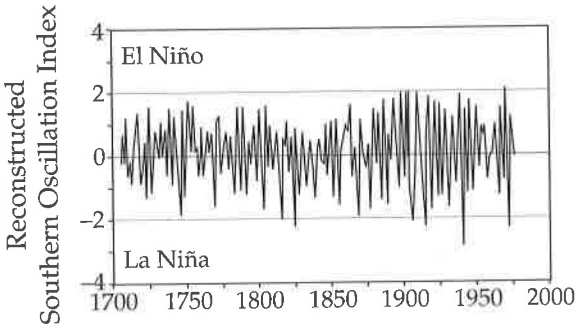


Figure 3. Historical reconstruction of the SOI using information contained in tree-ring growth records.

Figure 4.

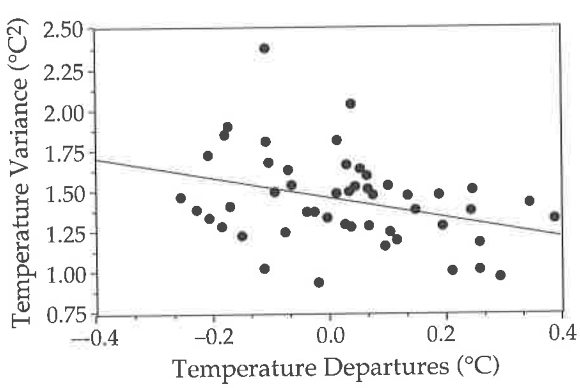


Figure 4. The month-to-month variance of temperature is negatively correlated with the average temperature departure. This means that warmer years have less variability than colder ones.

Figure 5.

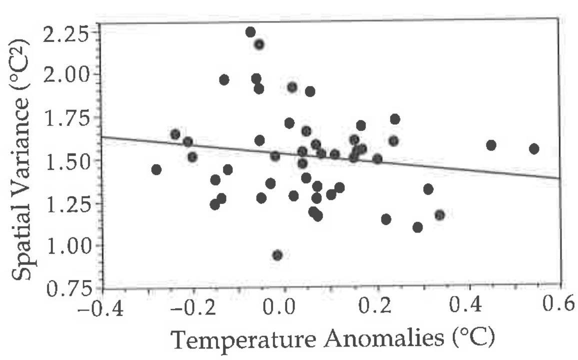


Figure 5. The spatial variance in temperature is negatively correlated to the average temperature anomaly. This means that temperature varies less from place to place during warmer years.

Figure 6.

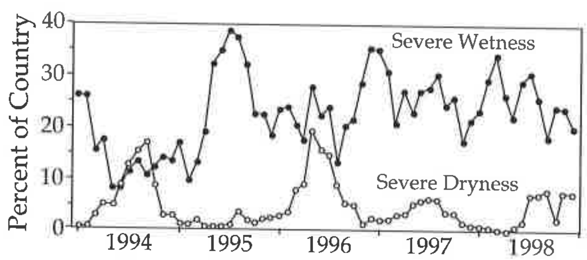


Figure 6. The percentage of the United States that has experienced severe wet conditions (filled circles) during the last five years far exceeds the percentage that has experienced severe dry conditions (open circles).

Figure 7.

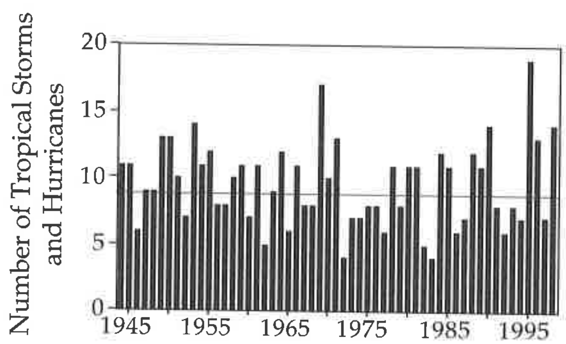


Figure 7. The number of tropical storms and hurricanes in the Atlantic Ocean since 1944.

other words, warm years have weaker temperature gradients. And since these temperature changes provide the energy needed to fuel middle and high latitude storms, we should expect fewer, weaker storm systems if greenhouse warming actually occurs.

From the standpoint of precipitation (which is primarily measured over land), globally speaking, 1998 was completely unremarkable, according to data from the U.S. Department of Commerce. despite all the so-called wacky weather. The global precipitation departure fell a mere 10th of an inch above normal. Precipitation was below normal in the tropics between 10 degrees north and south, but considerably above normal over the midlatitudes of the Northern Hemisphere. In the United States, the long-standing tendency for wet (as opposed to dry) conditions continued—1998 was the 5th-wettest year on record. In many areas, most of the rain fell in the first half of the year, when El Niño was still strong. Over the last five years, the percentage of the land area of the United States experiencing severe or extreme wet conditions far exceeded the area under drought (Figure 6). This tendency toward wetness over drought has persisted throughout much of the last century.

Hurricanes

Hurricanes always garner their share of press attention, and 1998 was certainly no exception. Hurricane Mitch, a very wet, very slow-moving storm, made landfall in an area of Honduras that was ill-prepared to deal with even a modest hurricane. With 14 named storms, the Atlantic tropical season was rather active. And once again, El Niño (or more specifically, its counterpart, La Niña) is to blame.

There is a well-established negative relationship between the number of Atlantic hurricanes and the strength of El Niño. In the long-term record of annual tropical storm and hurricane counts for the Atlantic (Figure 7), note the lack of storms during the El Niño year of 1997 (eight named storms) compared with 1996 and 1998. Had the El Niño persisted a few months into hurricane season, the 1998 number probably would have dropped. But El Niño started declining in strength just before the main Atlantic hurricane season, resulting in a high storm total.

The opposite situation occurred over the western Pacific. With only 17 named storms, 1998 was one of the most quiescent periods in the last 40 years.

Unfortunately, in this era of global warming philosophy trumping global warming science, misconceptions about the cause of major storms such as Hurricane Mitch abound. It is therefore incumbent upon climatologists to continue to set the record straight. There is no linkage between warm years and tropical cyclone counts. Figure 8 shows the number of tropical cyclones (tropical storms and hurricanes) in the Atlantic vs. global temperature departures from the long-term average. This is a classic random scatter plot—some warm years have few storms while others have many (1995, a warm, stormy year, stands out at the top right of the plot). The filled circles identify the last 10 years. Despite above-normal temperatures throughout the decade, five of those years had below-average tropical cyclone counts. The same holds for the real killer storms such as Mitch (Category 5 hurricanes on the Saffir-Simpson intensity scale). These storms are almost equally common in years in which the Northern Hemisphere is cooler than normal as opposed to warmer. The global warming–hurricane relationship only exists in the uncluttered minds of global warming philosophers, and not in the minds of global warming scientists.

Tornadoes

The only storm type more awe-inspiring than hurricanes is tornadoes, which have escaped the bad company of a global warming linkage. Until 1998, that is. In June, Vice President Al Gore connected the number of tornado deaths and global warming by indicating that the 122 deaths that occurred thusfar during the year was a record. This statement was flat-out wrong. Examination of the long-term tornado fatality records for the United States shows many high death counts in the 1950s, 1960s, and 1970s (Figure 9). This should come as a surprise to no one, of course, since tornado preparedness, warning systems, and building construction and code enhancements have saved many lives over the past few decades. Someone could just as mindlessly conclude, based on Figure 9, that global warming has saved thousands of American lives by reducing the number of destructive tornadoes.

So 1998 will be remembered as a year when the climate was hot and the rhetoric even hotter. The El Niño that dominated 1997–1998 will generate many legitimate scientific studies and will probably go down in history as one of the more significant climate events of the latter part of the 20th century. It also provides the context in which the record temperatures of 1998 must be placed. For if you see 1998 as the year when global warming began to take hold, then you must also expect similar weather conditions in 1999 and 2000, which are highly unlikely to experience a significant El Niño event. And if 1999 ends up as cold as 1998 would have been sans El Niño, we can only hope that the rhetoric of the global warming philosophers cools as much as our planet. ▲

Figure 8.

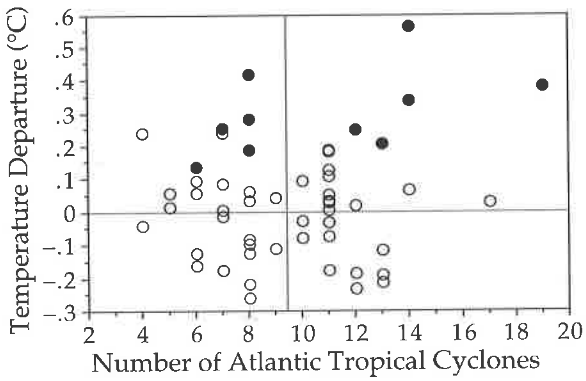


Figure 8. The number of tropical storms and hurricanes in the Atlantic vs. the global temperature departure. The filled circles are the last 10 years. While the last decade has been warmer than normal, the number of tropical storms and hurricanes is equally distributed above and below the mean (shaded vertical line).

Figure 9.

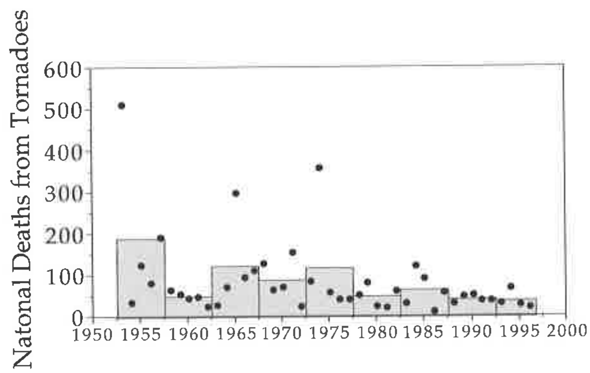


Figure 9. Annual number of deaths from tornadoes in the United States since 1953 (filled circles). The shaded bars represent the decadal averages.

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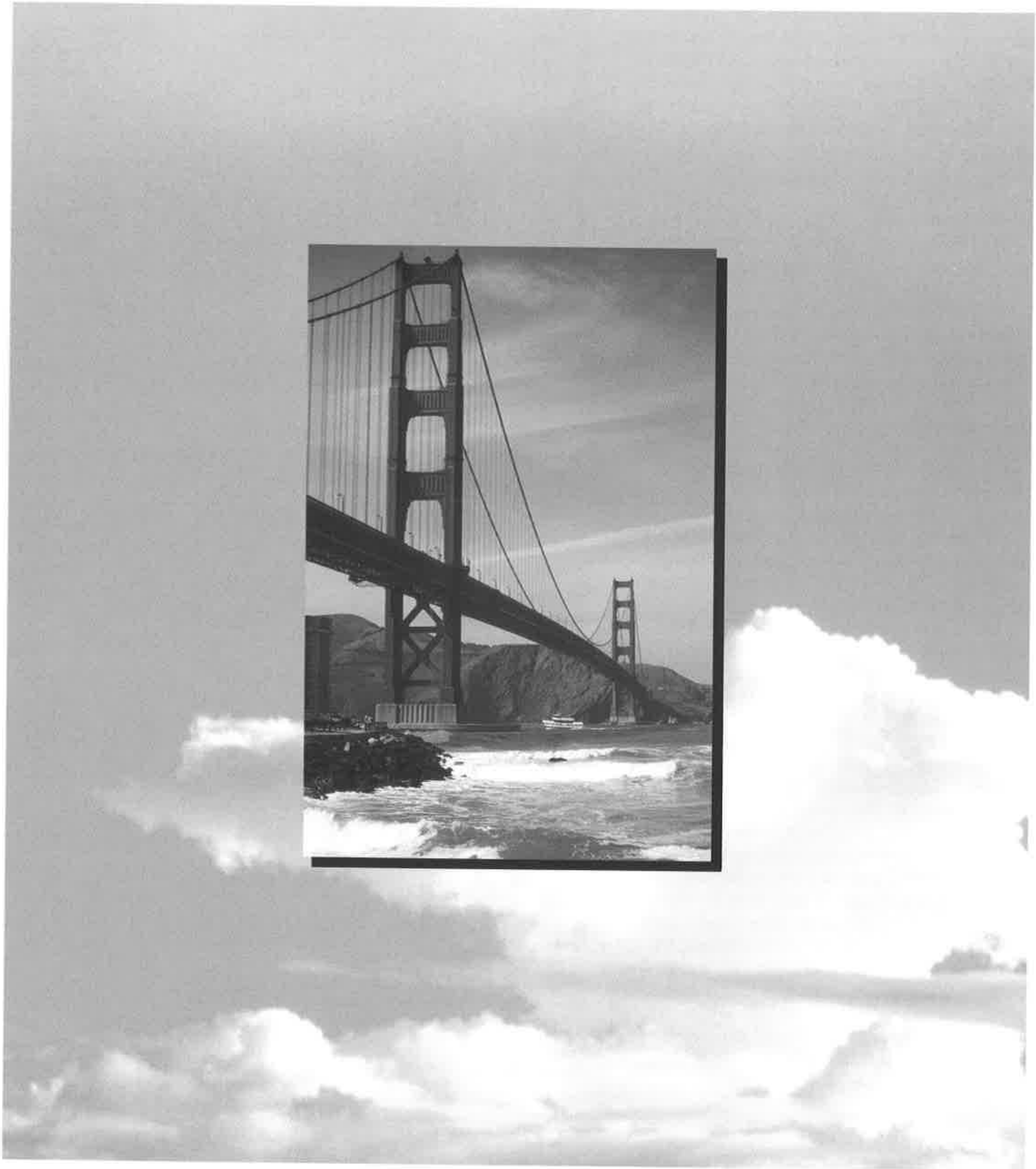


THE ABCs *of* CO_2

CARBON DIOXIDE'S MANY BENEFITS

BY CRAIG D. IDSO, PH.D.

Craig D. Idso is president of the Center for the Study of Carbon Dioxide and Global Change, where he has worked since its inception in January 1998, the same year he earned a Ph.D. in geography. With a B.S. in geography and an M.S. in agronomy, Dr. Idso brings a multidisciplinary background to the study of global and environmental change, including climatology and meteorology and their impacts on agriculture. Dr. Idso has published on issues relating to data quality, the growing season, the seasonal cycle of atmospheric carbon dioxide, and urban carbon dioxide concentrations.

How do I love thee? Let me count the ways. Elizabeth Barrett Browning's romantic poem perfectly captures the all-encompassing emotion of love. Though Miss Browning surely had human beings in mind when she wrote these words, she would not have been far off the mark if she were inspired by plants, for if plants could articulate their feelings we are sure that they too would recite these lines—to carbon dioxide. Carbon dioxide is an elixir of life, promoting the growth and vigor of the planet's plant life and, thereby, its animal life as well. Like love, carbon dioxide's many splendors are difficult to describe. Nevertheless, we shall try. Here, then, is your guide to the botanical benefits of atmospheric carbon dioxide, from A to Z.

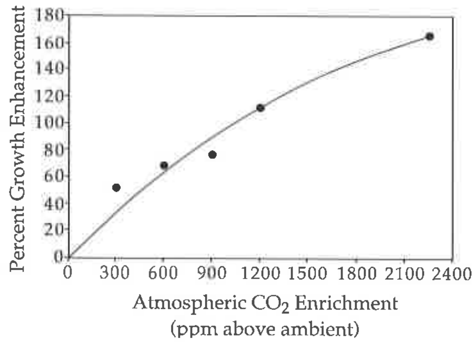
AIR POLLUTION STRESSES are generally alleviated as the air's carbon dioxide (CO_2) content rises; because with more CO_2 in the air, most plants reduce their leaf stomatal openings, thereby decreasing their uptake of gaseous air pollutants that might otherwise damage their tissues and, in the case of agricultural crops, reduce their yields (Reid and Fiscus, 1998; Volin et al., 1998).

BRANCH NUMBERS of most plants are typically increased under conditions of elevated atmospheric CO_2, due to the greater amounts of biomass produced under this favorable circumstance (Bucher et al., 1997; Tissue et al., 1997).

CELL SIZE in some plants has been reported to increase with atmospheric CO_2 enrichment (Ferris and Taylor, 1994).

Figure 1. Percent growth enhancement as a function of atmospheric CO_2 enrichment in parts per million (ppm) above the normal, or ambient, atmospheric CO_2 concentration. These data, representing a wide mix of plant species, were derived from 342 peer-reviewed scientific journal articles written by 484 scientists residing in 28 countries and representing 142 different research institutions. Adapted from the review of Idso (1992).

Figure 1.



DEFENSE MECHANISMS of plants are often enhanced by elevated concentrations of atmospheric CO_2, which tend to increase the amounts of defensive compounds in plant leaves as a deterrent against herbivore attacks (Lindroth et al., 1993; Gleadow et al., 1998).

ENHANCED EARLY GROWTH of plants is a phenomenon that is a frequent consequence of atmospheric CO_2 enrichment, often boosting their growth rates as early as the day that growth begins. This early stimulation is regularly found to be responsible for enhanced productivity in later stages of the plant's development (Miller et al., 1997; Farage et al., 1998).

FINE ROOT PRODUCTION is enhanced under elevated CO_2 concentrations, as is total below-ground growth in most plants. The primary role of fine roots is to take in nutrients and water from the soil (Idso and Kimball, 1991; Rogers et al., 1994).

GROWTH RESPONSES of plants to rising atmospheric CO_2 concentrations are evident in greater vegetative biomass production (Figure 1). For herbaceous plants, hundreds of observations of this phenomenon documented by Cure and Acock (1986), Mortensen (1987), Idso (1992) and Poorter (1993) have revealed that a doubling of the atmospheric CO_2 concentration increases plant biomass production by 30 percent to 50 percent. Most recently, Saxe et al. (1998) compiled and analyzed the results of more than 300 studies of woody plant responses to atmospheric carbon dioxide enrichment, determining that conifers and deciduous trees increase their biomass by 130 percent and 50 percent, respectively, in response to an approximate doubling of the air's CO_2 content.

HIGH TEMPERATURE STRESS is typically reduced or alleviated under elevated CO_2 conditions, because the higher CO_2 concentrations enable plants to maintain positive leaf carbon exchange rates in situations where they might otherwise lose carbon and die (Idso et al., 1989, 1995).

INTENSITY OF SOLAR RADIATION is not a limiting factor to plant growth at high CO_2 as it is at low CO_2—elevated CO_2 has often been observed to reduce a plant's light compensation point, or the light intensity at which the amount of carbon fixed by photosynthesis is equal to that lost by respiration. This phenomenon is especially beneficial to shaded vegetation growing beneath forest canopies that block out much of the incoming sunlight (Osborne et al., 1997). It also helps aquatic plants extend their life zones to greater depths below the surface of the water (Zimmerman et al., 1997).

JOINTLY SHARED FUNGAL NETWORKS that link plant root systems are often enhanced by atmospheric CO_2 enrichment (Rouhier and Read, 1998a; Walker et al., 1998). These networks have recently been observed to serve as pipelines for transferring nutrients from plants that have an abundance of them at their disposal to plants that are lacking in this regard, even between different species (Simard et al., 1997). Consequently, this phenomenon, which is enhanced by elevated levels of atmospheric CO_2, should help natural ecosystems to maintain high levels of species richness or biodiversity.

KEY ENZYME REACTIONS in plants are modified by atmospheric CO_2 enrichment in ways that enhance total plant growth. With more CO_2 in the air, for example, both the amount and activity of rubisco, which is the primary carbon-fixing enzyme in plants, are reduced. However, these reductions are beneficial to the plant in the long run (Osborne et al., 1998), for they allow for the transfer of nitrogen from the photosynthetic apparatus of the plant, where it is typically present in excess under ambient CO_2 concentrations, to areas of the plant where it would otherwise not be present in sufficient quantity to facilitate maximal growth (Bryant et al., 1998).

Low Temperature Stress may sometimes be reduced in plants growing in elevated CO_2 (Boese et al., 1997). In some cases, the higher CO_2 concentrations have actually enabled plants to grow to maturity and produce fruit, when control plants in ambient air died (Sionit et al., 1981).

Mycorrhizal Fungi that inhabit the soil and form symbiotic relationships with plant roots are nearly always benefited by the extra carbohydrates they obtain from CO_2-enriched plants. And in return, they typically enhance the soil nutrient and water gathering capacities of the plants, helping them to grow better still (Klironomos et al., 1998; Rouhier and Read, 1998b).

Nonstructural Carbohydrates, including glucose, fructose, sucrose and starch, are produced in greater quantities under elevated CO_2 conditions in nearly all plants. These important substances can then be transported to sites of new growth to support the plant's continued development (Korner et al., 1995; Poorter et al., 1997).

Optimum Growth Temperatures of most plants typically rise with increasing levels of atmospheric CO_2. For a 300 ppm increase in the air's CO_2 content, the temperature at which plants grow best has been observed to rise by a mean of approximately 6°C in a number of different species (Idso and Idso, 1994). This response is more than enough to totally compensate for the worst-case scenario of climate-model-predicted CO_2-induced global warming (Idso, 1995).

Photosynthetic Rates of the great majority of plants rise as the air's CO_2 content rises, resulting in substantial increases in growth and yield (Idso and Idso, 1994; Saxe et al., 1998).

Quantities of Animal Life should rise dramatically with the ongoing rise in the air's CO_2 content; for several studies have shown that the biomass of plant-eating animals in both terrestrial and aquatic ecosystems rises hand in hand with increases in ecosystem plant productivity (McNaughton et al., 1989; Cyr and Pace, 1993).

Root Production nearly always increases as a result of atmospheric CO_2 enrichment (Curtis et al., 1990; Rogers et al., 1994), often even more than above-ground biomass (Ceulemans and Mousseau, 1994). By increasing the size of taproots and the number and size of lateral roots (Entry et al., 1998), along with the ever-important fine-root biomass (Idso and Kimball, 1991), elevated CO_2 helps plants more effectively obtain the water and nutrients they need (Figure 2).

Figure 2.

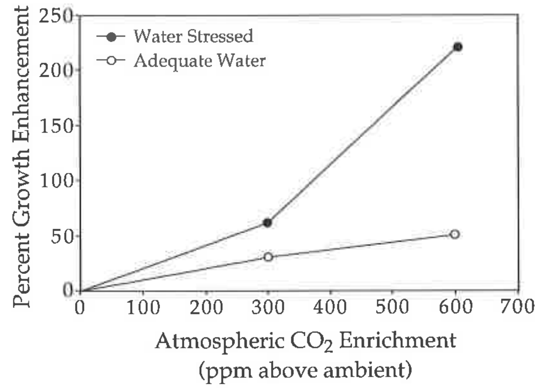


Figure 2. Percent growth enhancement as a function of atmospheric CO_2 enrichment in parts per million (ppm) above the normal atmospheric CO_2 concentration for plants growing under stressful and resource-limited conditions and for similar plants growing under ideal conditions. Each line is the mean result obtained from 298 separate experiments. Adapted from the review of Idso and Idso (1994).

Figure 3.

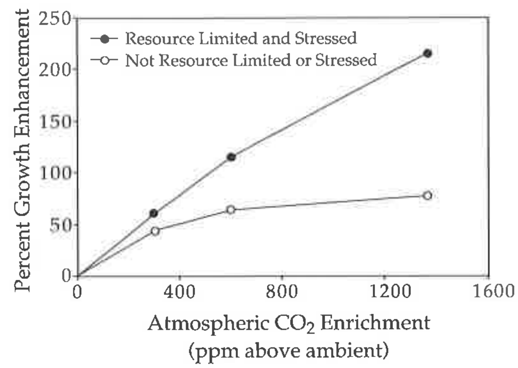


Figure 3. Percent growth enhancement as a function of atmospheric CO_2 enrichment in parts per million (ppm) above the normal, or atmospheric CO_2 concentration for plants growing under well-watered and water-stressed conditions. Each line is the mean result obtained from 55 separate experiments. Adapted from the review of Idso and Idso (1994).

Senescence in plants exposed to elevated CO_2 is sometimes accelerated, shortening the time it takes certain agricultural crops to reach maturity and thereby effectively decreasing the time that the crops are in the field (Hakala, 1998; Miglietta et al., 1998).

Transpiration, or plant evaporative water loss, is greatly reduced under atmospheric CO_2 enrichment due to CO_2-induced decreases in leaf stomatal conductance (Tognetti et al., 1998).

Uptake of Nutrients from the soil requires the expenditure of energy from plants. The near-ubiquitous CO_2-induced increase in leaf nonstructural carbohydrates can be used to generate additional energy for this purpose (BassiriRad et al., 1998). Also, greater quantities of organic acids secreted by plant rhizosphere organisms stimulated by their CO_2-enriched hosts hasten the chemical weathering of soil minerals and make them more available to plants (Molla et al., 1984).

VITAMIN CONTENTS of certain food crops may be enhanced by atmospheric CO_2 enrichment, as has been observed in tomatoes (Madsen, 1975) and bean sprouts (Tajiri, 1985).

WATER-USE EFFICIENCY, or the amount of carbon gained per unit of water lost, generally increases substantially with atmospheric CO_2 enrichment, sometimes even doubling with a doubling of the air's CO_2 content (Fernandez et al., 1998). In addition, when plants are growing under less-than-optimal conditions of soil water availability, the percent growth enhancement due to atmospheric CO_2 enrichment is generally greater than it is when water is readily available to them (Idso and Idso, 1994) (Figure 3). Elevated levels of CO_2 therefore tend to compensate for less than optimal water supplies (Arp et al., 1998); and they help plants recover more quickly and more completely when they have experienced a period of severe water stress (Ferris et al., 1998).

Xtra Carbon-Based Secondary Plant Compounds are also a consequence of CO_2 enrichment (Penuelas et al., 1997). Their presence in leaf tissues, particularly those of woody plants (Penuelas and Estiarte, 1998), may help protect forests from the ravages of certain pests.

YIELDS OF CROPS rise in tandem with the air's CO_2 content, as literally thousands of experiments have demonstrated (Kimball, 1983; Idso, 1992), increasing by about 30 percent for a 300 ppm increase in the air's CO_2 concentration (Cure and Acock, 1986; Mortensen, 1987).

ZONES OF VEGETATION will not have to shift poleward to keep up with climatic regimes to which they are currently accustomed if the globe warms in the future, as long as the air's CO_2 content continues to rise. Plants tend to like higher temperatures when the air's CO_2 content is higher (Idso and Idso, 1994). With CO_2-induced increases in plant water use efficiency, however, there will likely be an expansion of vegetative zones into areas of the world that are currently too dry to support them (Idso, 1995).

So there you have it, CO_2 enhancement from A to Z—Air pollution stress to a shift in the various Zones of vegetation. Were there more letters, we would surely continue, for these are just some of the many benefits of carbon dioxide on the biosphere. For to the biosphere, a molecule of CO_2 is a many-splendored thing. For plants, in particular, it is the very elixir of life. ▲

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A MAN AHEAD *of his* TIME

DISCUSSIONS WITH A CLIMATE CHANGE PIONEER

AN INTERVIEW WITH REID A. BRYSON, PH.D.

Reid A. Bryson considers "inter-disciplinary earth science with a strong humanistic component" to be his field of study. His pioneering work in developing new approaches to climatology includes airstream analysis and quantitative, objective methods of reconstructing past climates. After a stint in the Air Weather Service, Dr. Bryson joined the University of Wisconsin geology and geography faculties in 1946. He founded Wisconsin's meteorology department; the Center for Climatic Research (where he is still senior scientist); and the world-renowned Institute for Environmental Studies. Dr. Bryson has written more than 200 papers and five books and is at work on three more. The British Institute of Geographers calls him the most cited climatologist in the world. He earned his Ph.D. from the University of Chicago.

Madison, Wisc.—Chief Editor Patrick J. Michaels traveled to the University of Wisconsin's Center for Climatic Research in search of the origins of climate change science. There, he interviewed senior scientist Reid A. Bryson, Ph.D., who founded one of the first interdisciplinary institutes in the United States dedicated to studying the relation between climate and society. More than any other single scientist, Bryson is responsible for the notion that climate fluctuates in ways that are economically and socially important. Bryson proved his theory long before there were computer simulations of climate, with painstaking field studies on areas ranging from the Arctic to the Atacama Desert. One such study, of the Mill Creek Indian culture in Iowa, was particularly famous. By examining historical pollen records and other artifacts, Bryson and archaeologist David Baerreis determined that the climate of the Great Plains can undergo decadal shifts between drought and moist conditions. Federal climatologists have recently generated headlines by saying the same thing, only three decades later.

Long before the current computer models were developed, Bryson calculated the effects of carbon dioxide, volcanoes, and man-made aerosols on the climate. More than 20 years ago, he concluded that the dust effects were easily enough to dwarf greenhouse warming. Two decades later, when climate modelers searched for an excuse for the lack of predicted warming, they invoked human aerosols. Perhaps a few billion dollars would have been saved had we all listened to Bryson at the outset.

> "When I first brought up the idea that climate changes can occur on a short enough time scale to have important social and economic implications, I was accused of being 'full of it.'"

PJM: I understand that your interest in the weather started while you were growing up in the upper midwest.

RAB: Yes, I remember sitting in our kitchen in the drought years of the Thirties thinking, "Gee, it looks like it might actually rain." Then this big thunderstorm came along and I watched what seemed to be mud balls hit the window. It turned out that the raindrops were actually scouring dust from the air which came from Oklahoma and Kansas. I also remember the heat. It seemed like people were dying like flies, all over the place. Every day the newspaper would carry stories about the deaths like, "110 people died from the heat." The next day there would be only 95. The day after that would be something like 120 dead in the city of Detroit alone. There was no place to hide back then.

PJM: Well, the Dust Bowl eventually ended, and the climate actually cooled for several decades between then and the warming of the past few decades. Witnessing these changes first-hand must have been one of the inspirations for your interest in climate change, a topic to which you've devoted the better part of your career. Some people essentially say that you defined the field of climate change.

RAB: Whether or not I did, I have been studying climate and climate change for a long time. When I first brought up the idea that climate changes can occur on a short enough time scale to have important social and economic implications, I was accused of being "full of it." There were some very big, important scientists in this country who were saying, "Climatic changes are not big, and besides, climate always comes back to the mean, and changes always happen slowly, so it's nothing to worry about anyhow because we'll adapt." Now they're on the other side of the fence.

PJM: What happened?

RAB: I didn't change. It became worth money to take the viewpoint I was espousing, but I caught hell for it. In fact the leading climatologist from [the National Oceanic and Atmospheric Administration] at that time called me a Cassandra, not realizing that Cassandra's curse was that she was always right but nobody would listen!

PJM: What about our future climate with an increasing greenhouse effect? The most realistic estimates are that the global temperatures will rise somewhere between 1°C and 2°C during the next century. The accompanying forecasts are that extreme weather will become more common. Does this sound plausible?

RAB: Climate changes naturally and it changes everywhere. It changes rapidly, and it stays changed. It's a nonstationary time series, so you cannot define the mean.

I can show you in the published records that the variance changes by more than 50 percent from one set of decades to the other. In other words, it doesn't make sense to talk about how global warming will change the variance, because it will change by itself.

PJM: It seems like we read everywhere this year that El Niño becomes more frequent with global warming.

RAB: This is absolutely, flat-out wrong. Sandweiss saw it years ago when he showed that in the last 5,000 years there has been cold upwelling along the Peruvian coast, broken by intervals known as El Niño. Before 5,000 years ago there was always warm water, so there was continuous El Niño during ice ages, and cold water during interglacials. In other words, El Niño–type occurrences with warm water along that coast go with ice ages, not with warming. The fact of the matter is that the climate system is a pretty stable one. My old friend Eddie Lorenz started off by saying, "The flap of a butterfly's wings in the Amazon Valley..." and all that, implying a big positive feedback. But if there was that much positive feedback in the climate system, you and I would not be here talking about it, because in an unstable situation like that, civilization wouldn't have evolved so there wouldn't be any scientists to argue about it!

PJM: Well, what if the climate did change a bit? What would happen if the global mean temperature cooled a degree and and a half Celsius? After all, not many centuries ago it was cooler in many places.

RAB: Right. Northern Europe becomes less of a food supplier, Russia starves. In North America, not a lot of things change. It brings the Irish potato blight back.

PJM: These kinds of temperature changes were noted in your work on the Mill Creek Culture. It started out warm, and then the temperature dropped. What happened?

RAB: The big change was from about 1000 to 1150 A.D. The rainfall fluctuation was the main thing. During the warm period the rainfall was about 50 percent more than when it became cold. When it got cold, the westerlies shifted southward in the Northern Hemisphere [taking the rains with them]. In southern Illinois the precipitation reduction was apparently on the order of 75 percent, and that wiped out the Cahokia Middle Mississippian culture, leaving their frontier outpost here in Wisconsin high and dry. They disappeared!

PJM: Now warm the world up a degree.

RAB: In some areas it gets wetter, like in the Sahel [the area to the south of the Sahara Desert]; in some areas it gets drier, like in North Africa. Turkey becomes drier with a warming. It would probably improve the Russian rainfall and the Indian monsoons.

PJM: What about in the United States? Do you think that increasing the temperature of the globe a degree or so will increase the likelihood of climate fluctuations like these decadal droughts in the Great Plains?

RAB: No, I don't think so. My experience with climatic fluctuations suggests the warmer periods in Earth's history have been less variable than the cold periods. The way I put it 40 years ago—I think this is still approximately the truth—is that warm periods are dominated by sunlight, and cold periods are dominated by the lack of it, in part because of the modulation of volcanoes.

> "Climate changes naturally and it changes everywhere. It changes rapidly, and it stays changed. It's a nonstationary time series, so you cannot define the mean."

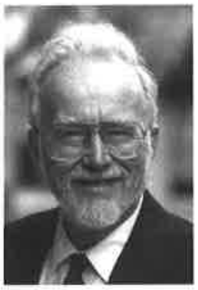
PJM: Sounds like there are a lot more things involved in climate change than just carbon dioxide.

RAB: I started the Institute for Environmental Studies at the University of Wisconsin in 1962 to conduct interdisciplinary research on climate and society. This was at a time when there were not many interdisciplinary science programs. Climate change is not a simple issue, with easily understood causes and effects. Nor are any of the big problems in society. Complex issues do not fall within the expertise of a single discipline. The only way you can deal with significant problems is to be interdisciplinary. You don't do that with a committee, because creativity is within the individual head. So you must train people to think, at a high level, in more than one discipline. This is the only way to even begin to understand what is going on.

You must first be able to answer the question of why climate changed before the advent of large-scale industry and only then can you start to explain how it might change afterward. ▲

BASKING *in the*
WINTER WARMTH
WHY HIGHER TEMPERATURES ARE BETTER

BY THOMAS GALE MOORE, PH.D.



Thomas Gale Moore *is the author of* Climate of Fear: Why We Shouldn't Worry About Global Warming *(Cato Institute, 1998). Dr. Moore is a senior fellow at Stanford University's Hoover Institution, where he specializes in international trade regulation, privatization, and the environment. He was a member of President Ronald Reagan's Council of Economic Advisers from 1985 to 1989, as well as serving on the President's National Critical Materials Council. In 1989, he served on the President's National Commission on Superconductivity. An adjunct scholar of the Cato Institute, he serves on the board of directors of the Competitive Enterprise Institute and the Independent Institute. He is also on the advisory board of the Institute for Market Economics in Sofia, Bulgaria. He received his Ph.D. from the University of Chicago in 1961.*

Last year was by all standards the warmest yet recorded. During the Little Climatic Optimum of 800 to 1,000 years ago, there were probably some years that were hotter, but thermometers and satellites necessary to verify the torrid readings were centuries in the future. In 1998, for once, ground-based readings and satellite measurements agreed that most places were warm and for most of the year. A large portion of the globe recorded those higher-than-normal readings. In the United States, all sections of the country, with the exception of the West, enjoyed higher-than-usual temperatures, often records for the year (Table 1). Relative to normal, the Northeast, the East North-Central, and the Central regions of the United States recorded the warmest weather. People may differ in their taste for sunny, warm days, but most of us evidently appreciated the absence of winter freezes: In response to the 1997–1998 El Niño–spawned weather, newspapers and magazines published a spate of articles describing the many benefits, and downright pleasure, that many found with the lack of a "real" winter. Interestingly, a warmth similar to 1998's occurred in Great Britain in 1995, and was the subject of a recently released British study. Here, we compare how people fared on each side of the Atlantic during these exceptional periods.

THIS SIDE OF THE ATLANTIC

TAXES. The *New York Times* reported Feb. 27, 1998, that the warmth had been a blessing for road-plowing budgets, had significantly reduced heart attacks from shoveling snow, and had improved commuter train service by virtually eliminating delays. Public works chiefs were cheering their virtually untouched bank accounts. Snow removal budgets and salt for the highways remained unused. During the "winter" of 1998, Greenburgh, N.Y., spent only $45,000 of its budgeted $325,000 for clearing the roads. With deliveries of oil down 20 percent, homeowners enjoyed significant savings on their heating bills.

The Philadelphia School District estimated spending on energy would be down by $1.5 million. For the state as a whole, government officials predicted expenditures on winter roads would drop by $20 million. The N.J. Department of Transportation boasted that the mild winter saved about a quarter of its winter budget.

ECONOMY. The good weather was generally good for business. Shoppers in the East and Midwest, lured by the balmy weather, turned out in force. In New York City, sales rose 5 percent in February, largely because of the weather. Construction companies, real estate agents, and transportation firms all benefited from the absence of snow and day after day of sunny skies.

Transport companies as well as consumers enjoyed the lowest gasoline prices since the World War II. Several factors contributed to the precipitous decline in gasoline prices: the collapse of several Asian economies and the consequent fall in the demand for energy; a partial lifting of the embargo on Iraqi production of oil; and, most important, a warmer world which reduced demand for heating oil, natural gas, and electricity. Energy prices fell across the board (Table 2). Minnesota, which enjoyed one of the warmest winters this century, reported that the weather was a boon for its economy. Minnegasco, the natural gas company, suffered, of course, from a 15 percent cut in sales. But the utility benefited from a sharp reduction in emergency repairs: in January, there were 21 percent fewer calls; in February, 13 percent fewer. Northern State Power, a major power company in the upper Midwest, also reported reduced sales of electricity, offset in part by lower expenses. On net, residents gained significantly—beyond just individual households' savings in heating bills of $135 to $150.

Roofers in the upper Midwest were able to do more business; field workers were less encumbered by heavy clothes, and tools were warmer and easier to use. In winter, milk delivery companies suffer when snow and ice create obstacles for their trucks. In 1998, in contrast, a major Minnesota dairy, Nelson Creamery, reported no delivery delays; during the more typical winter of 1997, the company had two truck rollovers; several other vehicles slid into ditches. The firm spent $1,200 for wrecker services in 1997; zero in 1998.

The good climate produced a bounty on the farm. Increased production meant lower incomes for farmers, but it also meant lower prices for consumers. Contrary to the assertions of global warming activists, who typically forecast crop failures, 1998's warm climate produced bumper crops. Farm prices were 13 percent below what they had been in the years 1992 to 1996.

LIFESTYLE. At driving ranges, golfers in record numbers improved their game. As the March 28, 1998, Sunday *Westchester Weekly* put it, "Golfers basked in a springlike glow almost straight through from November to March, the period that used to be known as winter." Golf courses enjoyed more business than ever. Spring fever was in the air. Even turtles and snakes were out much earlier than is normal.

The unusual weather did have a down side: Princeton sophomores bemoaned the lack of snow, which threatened the wintertime ritual of a nude midnight footrace through the Yard. Those who make extra money plowing driveways also were mourning the lack of white stuff. Towing services, which profit when cars get stuck, remained underused. Though consumers saved money on heating bills, gas and oil companies suffered from reduced demand, lower prices, and less revenue. There can be no sunshine without some sunburn.

HEALTH. The Minneapolis Post Office reported its mail carriers' sprained ankles and falls were down 40 percent. Only one postal worker got frostbite in 1998, compared with the normal tally of three or four. The absence of harsh weather also meant that service was smoother and more timely while overtime costs were down.

Global warming fear-mongers often predict that a warmer climate will kill people. That is not what happened in 1998. For the first 12 weeks of the year, overall deaths in New York City were down more than 8 percent from the 1996 levels and down 4.5 percent from the previous year. The next summer, one of the hottest on record, mortality was 6 percent lower than during the cooler summer of 1996 and, of course, it was lower (about 15 percent) than it had been during the winter.

PSYCHE. Winter's seeming absence provided mental and emotional benefits as well. Northern Westchester Hospital director of psychiatry Dr. Maureen Empfield said the weather improved people's moods: "Rarely does anyone come into my office and complain about sunshine." In Minnesota, airlines reported travel to sunnier climes was down, good news for Twin-Cities residents, though not for Northwest Airlines.

In the East, low-income elderly residents were delighted with more than just the savings on their heating bills. One octogenarian was deeply thankful for the warm sunny weather, which staved off despondency. Helen Nem complained that she suffers from depression when winter brings snow; 1998 was a year without gloom. And Ervin Pogue of Bucks County, Pa., bragged that this had been the best winter of his 77-year life. "This winter," he said, chortling, "I've had a ball."

At the zoo, tropical animals, normally inside all winter, were allowed out, much to the delight of the public and undoubtedly of the animals as well. Attendance was up 50 percent at the Philadelphia Zoo in January and February. Even birds benefited: the absence of snow cover meant that they had a plentiful supply of plants for food.

Table 1.

Average Temperatures by Region

Region	*Normal*	*1996*	*1997*	*1998*
Northeast	46.1	46.0	45.8	49.3
E. North-Central	43.5	41.5	43.4	47.7
Central	53.2	52.2	52.6	56.3
Southeast	62.4	61.9	62.4	64.7
W. North-Central	43.3	41.4	43.8	45.6
South	62.0	62.3	61.5	64.5
Southwest	51.8	53.8	52.3	52.8
Northwest	46.7	47.1	47.8	48.6
West	55.0	57.3	56.8	54.6
National	52.4	52.3	52.6	54.6

Source: Climate Variations Bulletin, Historical Climatology Series 4-7, December 1998

Table 1. Annual average temperatures for climate regions across the United States during the past three years.

ACROSS THE POND

The warmth of 1998 was also felt across the Atlantic in Great Britain, recalling a similarly warm time: 1995. Researchers recently completed a series of studies aimed at assessing how people got along during that warm year. The Global Atmospheric Division of the British Department of Environment commissioned the University of East Anglia to study the economic impacts of 1995's exceptional temperatures. Although they failed to put a dollar or pound figure on the results, they concluded that, by and large, it was a good year.

The university's Climatic Research Unit reported that the 12 months between November 1994 and October 1995 were the warmest in more than 300 years, and the summer was 3°C warmer than the 1961–1990 average. The East Anglia researchers detailed how the warm weather had affected various sectors. Their report on the natural environment was largely favorable, noting that "bird populations were in general favoured by the mild winter weather of 1995." Fewer algae blooms than expected meant water quality was maintained. The evidence showed that a sustained increase in temperature of 1.6°C (as in 1995) "would lead to a substantial increase in [forest] productivity." But in 1995 the well-being of certain deciduous trees, especially beech, did decline.

AGRICULTURE. Farmers benefited from the warmer weather: arable crops, like wheat, barley, oilseed rape, and sugar beets, did well; but the lack of rainfall hurt the production of potatoes and some vegetables. Irrigation, they pointed out, could mitigate those side effects. Unfortunately livestock farming did suffer, but the report stressed that sprinkling and dousing equipment could offset the effect of any warming on livestock. Freshwater trout farming also lost ground: Water oxygenation, the study noted, would eliminate those problems. In total, the British farming sector lost about £182 million (roughly $300 million at today's exchange rates), virtually all of which stemmed from livestock losses, which could be mitigated if the climate warms.

OTHER SECTORS. Moreover, savings in energy consumption more than offset those losses to some farmers. Consumers' natural gas bills alone were cut by £220 million (about $350 million). On net, including an increase in electricity used for cooling, the U.K. economy paid £355 million

Table 2. Consumer energy costs in 1998, compared with recent levels.

Table 2.

Consumer Energy Costs

Category	*1992–1996*	*1997*	*1998*
Gasoline	100	99.5	77.3*
Natural Gas	100	114.7	92.5**
Electricity	100	91.6	88.6**

*Average of the first eleven months.
**Average of the first ten months.
Source: Energy Information Agency, Department of Energy; http://ftp.eia.doe.gov/pub/

(nearly $600 million) less in energy costs.

The Climate Research Unit also found that people needed to spend less on clothing, reducing sales in that sector by £383 million ($600 million) in 1995. The population, however, consumed £134 million more in beer and wine and increased their purchases of fruit and vegetables by £25 million. The increased consumption of beer, wine, fruits, and vegetables suggests that warming would improve the British diet. In total, the researchers estimated that retail sales in 1995 fell by £87 million (about $140 million), reflecting a savings for households of the same magnitude.

The British construction industry, like its American counterpart, is subject to delays and interruptions during bad weather. The report claims that "in a warmer climate, the sector should be less affected by weather, since severe winter conditions, which cause the greatest disruption...will become less common."

The warm winter weather did improve transportation that season, though the hot summer weather led to increased rutting of the roads and higher maintenance costs. On net, the researchers found that the unusually warm conditions in 1995 boosted transportation costs by a trivial £16 million. Providing better asphalt would eliminate even that small cost while preserving the savings from reduced traffic delays and fewer potholes.

CLIMATE. The researchers also showed that, as in New York City, warmer weather reduced deaths. A 1°C increase in average temperature cut mortality by about 7,000 per year. Even a three-degree boost in average temperatures would reduce deaths, more in the winter than the summer, resulting in 3 percent fewer deaths or a saving in human lives of about 17,500 for England and Wales. According to the authors, the nice weather in the United Kingdom, again paralleling the United States, evidently led to "a decrease in winter depression," possibly to an increase in violent crime, but with increased levels of sociability. They were, however, unable to document these hypothesized changes.

ECONOMY. Although there was "some evidence" that December's sunshine affected 4th quarter gross domestic product (GDP), they wrote, the impact on the economy as a whole was minuscule. The researchers did find that the monthly Retail Price Index was sensitive to weather fluctuations and increased during long periods of hot weather, but they offered no explanation for this anomalous finding. Perhaps warm weather led to more spending, resulting in price increases. But if this were true, the GDP should have reflected the higher level of consumption.

In summary, the University of East Anglia researchers reported: "Clear positive impacts (to the general public) were found for energy and health." They added: "For most areas of human activity in the U.K. the greatest impacts are sustained from anomalous winter weather. In the transport and construction sectors, for example, activity is severely disrupted by severe winter weather, but the impact of very hot summer weather is by comparison small."

The hot years of 1998 in the United States and 1995 in the United Kingdom indicate that warm weather is good for human beings. People live longer; they spend more of their time outdoors; they save on energy and on clothing. Although people differ in their reactions, the great majority welcome winters that are a few degrees warmer. If we do get a warmer world, most men and women will echo Pennsylvania's Mr. Pogue and "have a ball." ▲

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