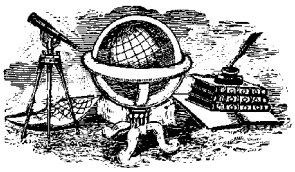
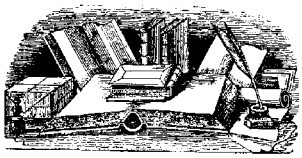
CLIMATE SCIENCE FORUM



Reliable News and Information on Climate Change



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http://climate-science.org

FROM THE EDITOR'S DESK

Our Purpose

Welcome to ***Climate Science Forum***, a newsletter that will provide credible and easily understood information in a matter of great world significance.

The newsletter assumes no editorial position in any matter of science or policy. Rather, our intention is to report the results of investigations in climate science, and their interpretations, that may be used to shape decisions on climate-related policies and strategies. Many prominent investigators have reached contradictory conclusions on whether and how the climate of Earth has changed, is changing or will change. This is frustrating to people making decisions that could affect the future of the planet. It also obscures the possible pathways that societies can take to deal with worldwide changes.

We are atmospheric scientists acting on a responsibility to transmit evidence of a possible alteration of the Earth itself, and the effects that may follow. Through this printed newsletter and its Web page equivalent, we will provide you with concise evidence of climate change and various interpretations of how climate has changed in the past, whether it is changing now, and what may be expected in the future. We shall not filter or censor the interpretations; rather we strive to balance hypotheses and interpretations as we present a range of evidence. This is a young and active science, very much in transition!

Each issue will include:

– Results of investigations in climate science, with citations and active links to the original articles. This issue focuses on the theme of abrupt climate transitions, past and present.

– Reports from conferences and meetings. This issue summarizes highlights of the American Meteorological Society annual meeting in Orlando, Florida.

(Continued on Page Two)

National Research Council Asserts Past Climate Change Speed 'Startling'

A December 10 report concludes that past changes of climate have occurred remarkably abruptly, and proposes a research agenda for determining the mechanisms of sudden change and their consequences. The National Research Council (NRC) report stated that "major and widespread climate changes have occurred with startling speed." As an example, one half of the temperature rise of the North Atlantic Ocean since the last Ice Age occurred over approximately 10 years.

"Abrupt climate changes were...common when the climate system was being forced to change most rapidly." Thus, the NRC suggests, if human alteration of the climate is taking place, the possibility of large and unwelcome climatic events is increased.

The report concludes, moreover, that "future abrupt changes cannot be predicted with confidence, and climate surprises are to be expected," because our knowledge of the nature of such abrupt changes is so limited.

In this issue of *Climate Science Forum*, a British climatologist has reviewed a wide range of work on this very issue of abrupt climate change (page 5). And our Climate Science Classroom explains the link between loss of ice in the Arctic, the circulation of deep water in the Atlantic, and sudden climate changes in Europe (page 7).

[The 205 page NRC report is available on line through the National Academy of Sciences: *http://www.nap.edu/catalog/10136.html?onpi_topnews_121101*].

QUOTE WITHOUT COMMENT

"The Kyoto-Bonn accord will make little progress in slowing global warming...if the Kyoto-Bonn Accord is implemented as designed, there is trouble ahead." — William D. Nordhaus, *Professor of Economics, Yale University*

(Our Purpose, from Page One)

The Conference on Global Change and Climate Variations was an important part of that meeting.

– A summary of policy initiatives under review in Congress, the executive branch, in the states, and in international bodies.

– A Climate Science Classroom. While the issues in climate science may be complex and involve many disciplines, it is vitally important that decision makers comprehend the basic points of agreement or the lack of agreement in the science. As an example, we explain in this issue how some believe that a warmer Arctic Ocean may stop the flow of warm water of the Gulf Stream to Europe.

– A Climate Forum, in which we invite two or more leading scientists to write contrasting viewpoints on a current issue in climate science

– Letters and commentary on information presented earlier.

Please browse this first issue, covering the period November 2001—February 2002. Let us know what information you need to see for your decision-making, and what you find that is, or is not, valuable.

We welcome your letters by mail or e-mail at *editor@climate-science.org* .

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Submissions will be welcomed by ***Climate Science Forum***, at our web site:
http://climate-science.org
The Internet version provides links to all studies and articles cited in this newsletter.

OF SPECIAL INTEREST

from the American Meteorological Society Annual Meeting, Orlando, FL, Jan. 2002

First Signs of El Niño in 2002: NOAA's Climate Prediction Center officially announced that warming is being observed over the Tropical Pacific, which could lead to an El Niño by early Spring. The U.S. is not expected to see its potential impacts until late summer, through the fall and into next winter. Read the story at *www.noaanews.noaa. gov/stories/s849.htm.*

(Continued on Page 3)

Does the Earth have an "Adaptive Iris"?

The American Meteorological Society (AMS) published a paper in which it was argued that the Atmosphere has a mechanism that resists any warming that may occur at the surface of the tropical Oceans. [See R.S. Lindzen, M.D. Chou, and A.Y. Hou, 2001: "Does the Earth have an adaptive Infrared Iris?", *Bulletin of the AMS*, v. 82, no.3, 417-433; online at *http://ams.allenpress.com/amsonline*]. It was dubbed the "Iris effect" in analogy with the iris of an eye, which opens to admit more light when illumination is dim, and closes to restrict light when illumination is strong. For the Earth, the "iris" is the high level "anvil" clouds of thunderstorms and the surrounding regions moistened by the ice from anvil clouds. These moist regions diminish the exodus of infrared radiation from the warm surface of Earth out to space; conversely, clear and dry skies allow the surface to cool rapidly.

For the Iris effect to occur, the moist area associated with anvil clouds must decrease in area when the sea surface becomes warmer. Lindzen and colleagues presented some evidence that higher amounts of cloudiness were associated with lower sea surface temperatures in their study area in the Pacific Ocean.

D.L. Hartmann and M.L. Michelsen (2002) have just published a critique ["No evidence for Iris", *Bulletin of the AMS*, v. 83, no. 2, 249-254], in which they disagree that the evidence provided by Lindzen really supports an Iris effect. They assert that the observed changes in cloudiness were far removed from the deep tropical "hot towers" of thunderstorms, and that there was no cause-and-effect connection.

Climate Science Forum will visit the evidence for and against the Iris effect in a forthcoming issue.

(OF SPECIAL INTEREST, Continued from page 2)

NOAA confirmed its assessment that El Niño conditions will appear within 3 months in a press release on Feb. 5. They also predict a warming of the sea surface off the coasts of Peru and Ecuador over the next few weeks.

Uncertainty in Temperature Projections: C.E. Forest and colleagues took a closer look at the probabilities of various outcomes in climate projections. They were able to reduce the range of uncertainty in one area – the cooling effect of aerosols – but broadened the range of uncertainty in "climate sensitivity", to a range of 1.4° to 7.7°C, for a doubling of atmospheric carbon dioxide. The upper limit in the IPCC 2001 Report is 4.5°C. Climate sensitivity is the expected temperature change on Earth for a given increase in a greenhouse gas. *Science*, v. 295, 113, 4 Jan 2002, (on line at *www.Sciencemag.org)*

100 Year floods more frequent in 20th century: In a recent report in *Nature*, v. 415, 514 (31 Jan 2002) (on line at *www.nature.com*), Princeton researchers found that great floods have increased in frequency in the last century. The record, which relies on measurements of river flow, is consistent with a positive trend they identified in simulations with a climate model.

Below: American Meteorogical Society (AMS) Policy Forum: What can the AMS do to better foster scientific services for society's needs? Panel (Left to right): Bryan Hannegan (Senate Committee on Energy and Natural Rerources), Jerry Skees (Professor of Agricultural Economics, University of Kentucky), Michael Crow (Professor of Science and Technology Policy, Columbia University), Ann Kellan (Science Correspondent, CNN)

Climate has Changed Rapidly Even in Warm Regimes

The old belief that climate is stable and relatively unchanging in the absence of human forcing is being evermore discarded. A new paradigm is emerging: that climates have shifted abruptly many times, and that the present climate may be expected to shift in any number of ways. "Surprises" are to be expected.

Most of the support for this new thinking comes from evidence of changes during the ice ages, or of sudden changes at the onset or termination of the ice ages (so-called "glacial events").

In this vein, J. Overpeck and R. Webb (2000) documented ways that the recent climate since the last ice age has shifted abruptly. Rather than cite evidence from the ice ages, they looked at recent changes during the "warm regime" of the last 10,000 years — which may be more relevant to today's situation.

The Pacific and El Niño: From studies of growth bands in coral, they note that the tropical Pacific climate was very different 7000 to 5000 years ago. For one thing, the El Niño phenomenon may have been totally absent. More recently, the variability of Pacific climate suddenly changed in the mid-1970's, so that, for example, El Niño variations have become more frequent since then.

Monsoons in Asia and Africa: Wet regimes have shifted to dry in a matter of a couple of years. Such changes in moisture have occurred multiple times. The demise of the Indus Valley civilization has been attributed to such a change.

North American drought: Persistent droughts left evidence of sand dunes and active sheets of sand in the High Plains of the U.S. The record suggests that the current climate is relatively wet and free of severe drought. Before 1200, droughts were severe and frequent.

Their article, "Nonglacial Rapid Climate Events: Past and Future," is found in *Proceedings of the National Academy of Sciences* (Feb 15, 2000), v. 97, no. 4, p. 1335; on line at:
www.pnas.org/cgi/content/full/97/4/1335 .

Book Shelf

The Skeptical Environmentalist

by Bjorn Lomborg

Excerpts from *The Skeptical Environmentalist*: *Measuring the Real State of the World* (Cambridge University Press, 2001): Chapter 24, Global Warming. Bjorn Lomborg is professor of Statistics, University of Aarhus, Denmark. Reprinted with permission.

"It is true that temperature has increased, although mainly at night, in the winter, and in cold places. Such reduction in cold extremes without increasing heat extremes has in many respects been beneficial, but if the warming continues, eventually heat extremes will also take their toll.

"To sum up, **the IPCC business-as-usual scenario …leads to overestimates in the speed of global warming.** We will still use predominantly fossil fuel at the end of the century. Yet such a scenario is unlikely … Rather more plausible assumptions point to almost complete fossil fuel substitution over the 21st century, drastically limiting global carbon emissions, and restricting temperature increases . . .

"We will undoubtedly still use fossil fuels for many years to come. In order to handle global warming, we need not necessarily phase out fossil fuels rapidly. Instead we need to make sure that . . . sun, wind, and fusion will become competitive energy sources before or by mid-century. This will cost much less and give rise to only a smaller temperature increase.

"However, global warming will have serious costs – the total cost is about $5 trillion. The consequences will hit the developing countries hardest, whereas the industrialized countries may actually benefit from a warming lower than 2° – 3°C. Economic analyses clearly show that it will be far more expensive to cut CO_2 emissions radically than to pay the costs of adaptation to increased temperatures. . . A key conclusion of all economic modelers was: 'Current assessments determine that **the optimal policy calls for a relatively modest level of control of CO_2.**' "

CRITIQUE

by Stephen H. Schneider, editor of *Climatic Change* and Professor of Biological Science, Stanford University (Reprinted from "Global Warming: Neglecting the Complexities," *Scientific American,* January 2002 [*www.sciamarchive.org*]. Copyright © 2001 Scientific American Inc. All rights reserved).

On cost-benefit calculations: "Lomborg cites only one value for climate damages - $5 trillion - even though the same papers he refers to for costs of climate policy generally acknowledge that climate damages can vary from benefits up to catastrophic losses.

"It is precisely because the responsible scientific community cannot rule out such catastrophic outcomes at a high level of confidence that climate mitigation strategies are seriously proposed. And to give one number - rather than a broad range - for climate damages defies explanation, especially when he does give a range for climate policy costs.

On emission scenarios: "Lomborg asserts that over the next several decades new, improved solar machines and other renewable technologies will crowd fossil fuels off the market. This will be done so efficiently that the IPCC scenarios vastly overestimate the chance for major increases in carbon dioxide. How I wish this would turn out to be true! But wishes aren't analysis. One study is cited; ignored is the huge body of economics work he later accepts to estimate a range of costs if we were to implement emissions controls. In fact, most of these economists strongly believe high emissions are quite likely: they usually project carbon dioxide doubling to tripling (or more) as 'optimal' economic policy. I have attacked this literature for failing to point out that climate policies that raise the price of conventional fuels spur investments in alternative energy systems. But such incentives need policies first, and Lomborg opposes those very policies."

To conclude: "So what then is 'the real state of the world'? Clearly, it isn't knowable in traditional statistical terms, even though subjective estimates can be responsibly offered. The ranges presented by the IPCC in its peer-reviewed reports give the best snapshot of the real state of climate change: *we could be lucky and see a mild effect or unlucky and get the catastrophic outcomes*. The IPCC frames the issue as a risk management decision about hedging. It is not the everything-will-turn-out-fine affair that Lomborg would have us believe."

Abrupt Climate Transitions Regarded as Frequent, Unpredictable

Major Review of Past Climates Challenges Assumption that Climate System is Stable

The Royal Meteorological Society recently published a review of work on "Sudden and Abrupt Climatic Transitions and Fluctuations" [J.G. Lockwood, 2001: *International Journal of Climatology*, v. 21, p. 1153-1179; on line at *www.royal-metsoc.org.uk/ijc01.html*]. Lockwood's review is worth highlighting in these pages for its breadth of vision.

His basic tenet is that climate is an unstable system which is not, and never was, at equilibrium. Using "systems theory", he explores the behavior of unstable systems as they evolve. At a "bifurcation point" the system may "choose" among various regimes, and the fluctuations become large. In other words, it shifts away from its previous climate state to a new state in which properties take on new average values. Even the range of values, and the variability, can change.

This is more than a mere academic exercise. Lockwood has assembled a wide range of evidence from the historical period, the Holocene (the warm era from the last Ice Age up to the present), and the last Ice Age itself, to show that climate has shifted abruptly in numerous ways, a number of times.

Understanding is growing that the climate is not stable, but switches from one state to another in a matter of years or decades. Climate changes abruptly on every time scale. On seasonal (very short) scales, the whole circulation of the Asian monsoon begins on a matter of a day or days. On century scales, sudden advances of glaciers occurred every 200 to 400 years. On scales of a millenium, both the onset and the termination of the so-called "Little Ice Age" were sudden, judging from an analysis of ice cores –- the shift was as sudden as the ice core can possibly show.

The last glacial period ("Ice Age") lasted from 115,000 to 10,000 years ago, but it included at least 24 "sudden warmings" in an otherwise cold climate, according to several investigators of the Greenland ice core. The sudden warmings occurred over "a few decades or less." Extreme and short-lived cold episodes, or "Heinrich events," also recurred in the glacial period. Lockwood attributes these events to complete shutdowns of the North Atlantic deep water circulation. See the Climate Science Classroom (page 7) for an explanation of the thermohaline circulation.

In the 20th century, the Arctic region warmed 3 times since 1970, with the strongest warming in the 1990's. The spatial pattern of temperature of Arctic Ocean waters also underwent a change. In the Tropics, a shift in the behavior of El Niño occurred in 1976. Before then, the frequency of El Niños was like it was 124,000 years ago; since 1976, the frequency has been "distinctly different."

Lockwood is saying that climatic "equilibrium" is difficult to find anywhere, even in the tropics, for any time period. We have new evidence of sudden shifts and oscillations in periods previously regarded as stable. Computer simulations of a world with CO_2 levels from 2 to 4 times the present level suggest that at some point, the thermohaline circulation shuts down, as it has done in the distant past.

"Climate changes in the past have not always taken place in a slow, smooth manner. It is most unlikely that future changes associated with present . . . warming will be smooth. We could, therefore, be in for some climatological surprises!"

Below: French, Russian, and American scientists of the Greenland Ice Sheet Project-2 (GISP-2) hold ice cores containing a "frozen record" of global changes over the past 110,000 years. The Project is managed by the University of New Hampshire and funded by the National Science Foundation. (Photo: Todd Sowers, Columbia University, and the NOAA Paleoclimatology program.)

Bush Administration Outlines Climate Policy

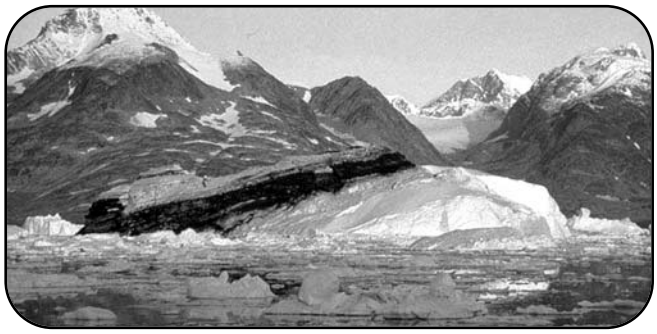
The Bush administration outlined its first policy package for dealing with greenhouse gasses and future climate change, in a speech the President delivered to NOAA on Feb. 14. The policies emphasize voluntary agreements with industries, tax incentives, more resources for renewable energy sources, and a new measure of greenhouse gas impact. The climate policy is summarized in the box at the right.

At the same time, the President delivered a policy initiative for limiting emissions of three traditional air pollutants emitted by power plants: sulfur dioxide (SO_2), nitrogen oxides (NOx), and mercury.

The two policies were quite different. Mandatory emission limits are proposed for the three traditional pollutants by the years 2010 and 2018, with at least a two-thirds reduction from this year's emissions required by 2018. The proposal only addresses power plant emissions.

Under the climate policy, the Administration does not mandate fixed ceilings on greenhouse gas emissions; rather it proposes limits which are tied to economic growth. In order to measure progress, the President proposed a new measure: *greenhouse gas* (GHG) *intensity.* The goal is to reduce this GHG intensity by 18% from 2002 to 2012.

Whether emissions are actually reduced will depend on the level of economic activity. With a fixed goal of greenhouse gas (GHG) intensity, allowable emissions of CO_2 may be greater when the GDP is greater. In order to attain a targeted rate of emissions (which is not what the Administration proposes; but the Kyoto protocol does), the GHG intensity goal would have to be set lower when the GDP is higher, when the economy is strong. The intensity goal could be higher (a more relaxed, easier policy) when the economy is weak.



Highlights of Climate Policy Initiative

Both policies are described on line at:
www.whitehouse.gov/infocus/environment/

Goal for Greenhouse Gases: Sets a goal for Greenouse Gas emissions, relative to economic output. Proposes a new measure of compliance : the greenhouse gas intensity, defined as the ratio of emissions of equivalent greenhouse gas in tons, to the gross domestic product (GDP) in dollars.

The goal is *an 18% reduction over 10 years* from 2002 greenhouse gas intensity levels.

Fuel Economy: Directs Dept.of Transportation (DOT) to reform the Corporate Average Fuel Efficiency (CAFÉ) program, and to propose new standards; seeks $3 billion in tax credits over 11 years for purchase of new hybrid or fuel cell vehicles. “Freedom car” initiative, a program to promote hydrogen as the primary fuel for cars and trucks.

Tax Incentives for “Clean Energy” Sources:

Proposed tax credits of $555 million in FY 2003, and $4.6 billion over 5 years:

◆ to spur investments in renewable energy (solar, wind, and biomass), hybrid and fuel cell vehicles,co-generation of space heat and electricity, ethanol fuel, and landfill gas recovery.

◆ tax credit for residential use of solar power.

◆ tax credits to individuals of $4000 for a new hybrid vehicle and $8000 for a fuel-cell vehicle.

“Methane First” Strategy for lowering emissions of greenhouse gasses, because methane is more active than CO_2 in the atmosphere

Carbon Storage: Requests $1 billion more than the $3 billion baseline for the land conservation program of the Dept. of Agriulture

Science and Engineering Funding: Seeks a $700 million increase (an 18% increase) in climate science and technology funding (a total of $4.5 billion).

◆ a new science effort, the "Climate Change Research Initiative" will receive $40 Million, to address major gaps in understanding of:

The natural carbon cycle
The role of black soot in climate change
The role of aerosols in climate change

◆ a new engineering effort will receive $40 million for development of the most promising "breakthrough" technologies in renewable energy.

(Left) Melting glacier in Greenland may affect the thermohaline circulation of the Atlantic

Climate Science Classroom

Warm Gulf Stream and Arctic Sea Ice: *what's the connection ?* The Thermohaline Circulation

Earth science is constantly finding surprising connections between distant parts of the globe. A good example is the mutual influence of warm tropical ocean currents, such as the Gulf Stream flowing by the East coast, and the frozen Arctic Ocean. Their influence on each other may have played a role in causing the abrupt climate changes that have plagued Europe and North America.

The best example of a major change is the advance and retreat of the massive ice sheets that covered Canada and part of the United States, as well as Europe and Russia, five separate times during the era when humans lived on Earth. The Little Ice Age from 1350 to 1850 is another example of a cool period that began and ended rather quickly. We have included several articles on the theme of abrupt climate change in this issue.

So what do the Gulf Stream and the Arctic ice sheet have to do with climate change? Let's cover some basics:

The tropics warm up a great deal. The excess heat in the tropics naturally flows into colder regions around the Poles. The oceans transport about a half of this energy, while the Atmosphere carries the rest. If we look at a globe, we see that the Indian Ocean has no connection with the Arctic, and the Pacific Ocean connects with the Arctic only at the narrow Bering Strait. This Strait is quite shallow; it is believed that Asian peoples walked across it to Alaska when the sea level was lower, and begat Native American peoples. Only insignificant amounts of water get through the Bering Strait. That leaves the Atlantic Ocean as the only ocean with a broad, deep channel to the Arctic.

Warm water is lighter than cold water, so it floats on top. Fresh water is lighter than salty water, so it also floats on top of brine. Very warm water in the tropics (85°F) spreads northward to the polar latitudes. In the Atlantic, this warm current is the Gulf Stream, which provides northern Europe with a milder climate than that of Canada. While releasing its warmth to the atmosphere, the waters of the North Atlantic are chilled by frigid air in the region between Norway, Greenland, Iceland, and the Arctic ice pack. The chilled water sinks and fills the deep basin of the Atlantic, flowing over the bottom all the way to the tropics and even farther, into the South Atlantic. "And so the cycle is complete." This cycle is called the thermohaline circulation.

If the chilled water is salty, it will sink because salty water becomes heavier as it cools to the freezing point. BUT fresh water is different: as it cools to 4°C (39°F), it becomes heavier; but when it cools even more, it starts to become lighter – until it freezes into ice, when it becomes lighter still. This is why ice floats. Fresh water that is colder than 4° C floats on top of water right at 4° C; and the two layers do not mix easily.

When ice forms from fresh water, the ice layer cuts off almost all the heat flow from the ocean to the air. Salty water, though, would rather sink than freeze. So where the cold ocean is salty, the sinking of cold water drives the thermohaline circulation; but where the cold ocean is not-so-salty, ice forms, and little or no circulation ensues in the ocean.

Four large rivers drain from the Russian mainland into the Arctic Ocean, and the Mackenzie River drains from Canada. All this fresh water spreads over the top of the Arctic sea water, and readily freezes into the Arctic ice pack. A large fraction of the ice melts every summer. It does not require much atmospheric warming to melt the ice pack and reduce its area significantly.

A large amount of melt water, or fresh water from rivers, is thought to inhibit the thermohaline circulation in the Oceans, because it tends to remain on the surface of the Arctic Ocean instead of sinking, as salty water does.

There is evidence that a complete shutdown of the circulation has happened in the past. Model simulations give circumstantial evidence that it might be possible in the future, with some of the larger projected temperature increases. The National Research Council concluded that a complete shutdown of the thermohaline circulation was "unlikely" in the next 100 years, but could not rule out the possibility.

Year 2001 Climate in review: Warm

The National Climate Data Center (NCDC), in Asheville NC, reported that last year was the second warmest ever observed. The only year warmer than 2001 was 1998, when a strong El Niño boosted Pacific sea surface temperatures.

The temperature trend itself has accelerated. Over the 20th century, the temperature of Earth was observed to increase at 0.6°C per century, but the rate has been 2.0°C per century since 1976. There were two periods of rapid rise, the first in 1910 – 1945, and the second over the last 25 years.

There is still a large difference between the rate of warming on the surface of the Earth and in the lowest layer of the atmosphere (from 0 to 8 km). This difference has been the source of controversy. The lower atmospheric has warmed only +0.3°C per century over the last 20 years, a rate that is 6 times slower than the warming rate at the surface.

In May and August last year, more than one-fourth of the nation was "very warm", while in November two-thirds of the US was "very warm." The phrase "very warm" is used to refer to the warmest 10% of all temperatures observed in the climatic record.

The portion of the country experiencing severe to extreme long-term drought increased to 20% of the nation by October, while the portion experiencing a severe to extreme wet spell was only 4%.

The drought last year really began in 1999 in the Pacific Northwest and the Atlantic coast. Washington, Oregon, and Idaho declared drought emergencies, and record numbers of wildfires were fought in those States. In the Northeast, nine months of the year were dry. Maine had the driest year on record; the Appalachians had the worst wildfire season in 10 years. Full details can be viewed on their web site: *http://lwf.ncdc.noaa.gov/oa/climate/research/2001/perspectives.html*

The NCDC also reported that the three-month season from November 2001 through January 2002 was the warmest such period ever observed in the United States, in records going back to 1895. The most pronounced departure from previous conditions was observed from Minnesota to New England. Details can be viewed at:

http://lwf.ncdc.noaa.gov/oa/climate/research/2002/jan/national.html#3month .

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