NAVIGATING OPINION IN SEARCH OF FACTS

Lesson Concepts: Students will evaluate issues of public concern and differentiate between data supported hypotheses and claims based upon opinion. They will develop and use tests to evaluate components of mutually exclusive ideas, recognize components of propaganda, and engage in civil discourse concerning diametrically opposed viewpoints.

Learning Objectives — Students will be able to:

- **Investigate articles expressing opposing viewpoints and citing conflicting analysis of data concerning global climate change as they appear on the Internet.**
- **Search for data supported facts as opposed to opinion supported with conjecture or partial supporting data on the issue of global climate change.**
- **Determine point of view of the author citing facts from a respective viewpoint.**
- **Chart opposing ideas concerning global climate change and arrange them into pairs that are irreconcilable.**

Grade Level: 12

California History-Social Science Standards

Grade 12 American Democracy. 12.3 Students evaluate and take and defend positions on what the fundamental values and principles of civil society are (i.e., the autonomous sphere of voluntary personal, social, and economic relations that are not part of government), their interdependence, and the meaning and importance of those values and principles for a free society.

12.6 Students evaluate issues regarding campaigns for national, state, and local elective offices.

Grade 12 Economics. 12.1 Students understand common economic terms and concepts and economic reasoning.

12.3 Students analyze the influence of the federal government on the American economy.

12.5 Students analyze the aggregate economic behavior of the U.S. economy.

Education and the Environment Initiative
Educational Principles and Concepts

Principle IV: The exchange of matter between natural systems and human societies affects the long-term functioning of both. As a basis for understanding this principle:

Concept b. Students need to know that the byproducts of human activity are not readily prevented from entering natural systems and may be beneficial, neutral, or detrimental in their effect.

Link to *Air –The Search for One Clean Breath* from Executive Producer Barbara L. Page

In the film, we show 18th century scientist and scholar Joseph Priestly investigating the scientific mysteries of air. In this lesson, students will also do some "investigating" about air - - but this time they will use the *Socratic Method* as their guide.

Materials

- Articles for student groups to read.
- Support documents.

Advanced Preparation

Duplicate articles for students to read or have available online. Review the content of articles.

Time and Student Grouping

Three 50 minute class periods. Entire class for brainstorming, summarization, and structured discussion of topics. Duos or triads to read and summarize articles.

Procedure: A basic discussion of ideas from viewing the film is appropriate. This could be assigned as homework so that students can prepare their ideas concerning a topic.

Vocabulary

Refutability: To prove something to be false or somebody to be in error, either through logical argument or by providing evidence to the contrary.
Empirical evidence: Originating in or based on observation or experience; relying on experience or observation alone often without due regard for system and theory; capable of being verified or disproved by observation or experiment.
Propaganda: Information put out by an organization or government to promote a policy, idea, or cause; deceptive or distorted information that is systematically spread.
Hypothesis: A tentative explanation for a phenomenon, used as a basis for further investigation; a statement that is assumed to be true for the sake of argument; in logic, the antecedent of a conditional statement.
Parts Per Million (ppm): A unit of concentration often used when measuring levels of pollutants in air, water, body fluids, etc.

Teacher Background

Informed citizens should be able to distinguish between empirically based understandings and propaganda. Articles accompanying this lesson are samples of scientific papers and blogs concerning the issue of human introduced atmospheric CO_2 concentrations and if those concentrations are the cause of global climate change. Also within the articles there is discussion, to some degree, if we are experiencing a human influenced change at all.

Articles chosen to support this lesson also include commentaries speculating on the affect of the Media approach to covering issues of high interest. While some articles on the resource page contain explicit examples of how ideas and facts represent various techniques of expressing a thesis, other articles which simply relate current data may need to be updated from school year to school year.

Students, and perhaps teachers, may want to rally to support one side or the other based on an emotional response to an argument. This lesson is intended to be an exercise in putting that emotional component aside and truly examining the nature of the evidence supporting the hypothesis. Invoking emotional response is a strong propaganda tool. See resource page for synopsis of each of the articles selected to support the lesson.

The science of the lesson: This lesson is designed for social studies, history, and civics courses. Although it is inquiry-based, it does not involve hands-on activities or direct involvement in scientific method. Some understanding of Earth's geologic history and methodology of determining data from fossil evidence is necessary.

Procedure continued

Day 1:

1. Ask students how we know the information presented in the movie is factual? Discuss if the facts presented in the film may have been incorrect or false.
2. Introduce the two articles that the class will read that present opposing viewpoints in relation to global climate change: *Are Carbon Dioxide and Fossil Fuels Responsible for Global Warming*? by John Coleman and *What the World Needs to Watch* from the CO_2 Now website. Use the student worksheet for reading guidelines:
   - List topic
   - List unfamiliar vocabulary
   - What are important pieces of information that you gained from reading and discuss the article with your group?
   - What proof in support of the hypothesis did the author offer?
   - Did the author express his/her opinion in the article?
   - Is the article opinion or data backed?
   - Did the article leave you with any questions?

Teacher Tips

The purpose of this lesson is to introduce students to the methodology of analyzing various viewpoints and to show how empirical evidence can be used and understood. Remember, opening minds is the cause of free thinking in students.

Refrain from asking if students agree or disagree with thesis of article; they will voice their opinions in any case. Allow students to make one statement based on previous understandings and/or personal belief, but guide the focus of discussion toward evidence and data provided in each article. It will be counter-productive for students to engage in a right/wrong discussion without understanding the evidence.

Many students resist reading for content for various reasons. Veteran teachers combine and develop techniques designed to support the students' engagement in forming their own views presented in writing.

New teachers will want to consider approaches to the reading task such as: grouping students in triads to share reading task; prompts that focus students' action on expressing main points of the article; or use of graphic organizers to disaggregate main points.

Procedure continued

3. Provide and review resource page, Recognizing Propaganda with students. Ask students if they read any statements in their article which could be defined as *propaganda*.
4. Ask students to state the main thesis of each article. Post the main ideas on a large graphic organizer. The organizer is divided by the two articles.
5. Identify statements which are opposing or mutually exclusive of each other.
6. Discuss the concept of mutual exclusivity and how if one idea is true the other cannot be true.
7. Ask students to identify if there is supporting empirical data within the article for each of the ideas.

Day 2:
1. Review with students about how they might know if information presented to them is data-based or a strong idea based opinion.
2. Move students into activity of reading and discussing articles with opposing viewpoints. See attached resource sheet Synopsis of Articles.
3. Students will follow the same procedure as in the previous day to determine points made by the author(s), organize statements on a graphic organizer divided into 'CO_2 as a cause of global climate change' and 'climate change naturally occurs' (which would include denials of any change).
4. **Note:** Lesson includes articles with data, which is in the form of tables and background information concerning topics which are referred to in the articles. Groups who read informational articles will act as 'experts' in the area and will be contributing to the class discussion in that capacity. Encourage them to make graphs/graphics to illustrate necessary understanding.
5. Student groups read an article. Summarize the main points. Use a worksheet to summarize their articles. Students will make note of propaganda techniques and statements lacking credible evidence in their summaries.

Day 3:
1. Student presentations. The goal here is for students to discuss and disaggregate themes, data, and ideas from articles more so than debating correct/incorrectness of thesis.

Support Resources:
- Student Reading Guidelines
- Recognizing Propaganda Techniques and Errors of Faulty Logic
- Synopsis of Articles
- Articles for lesson

Closure: Ask students about the difficulties involved in deciding that one thesis or the other is correct. Allow students to dialogue about these issues. However, remind them of the need to scientifically examine evidence that is measurable.

Resources: See attached articles.

Assessment: A written or individual summary presentation by student of this event may be used as a summative assessment of objectives/standards. Use one or both of the following anonymous quotes as a prompt for students to respond to based upon their experience analyzing the articles:

"What evidence would it take to prove your beliefs wrong? I simply will not reply to challenges that do not address this question. Refutability is one of the classic determinants of whether a theory can be called scientific. It's easy to criticize science for being 'closed-minded'. Are you open-minded enough to consider whether your ideas might be wrong?"

"I do not 'believe' in the IPCC, in the AGU, in the Hadley Centre, in 2,500 scientists and experts, in Svensmark, in Lindzen, in Crichton, in yourself, in SciAm, in American Scientist, in any skeptic or AGW believer. I take everybody's remarks as a step forward in the discussion and in the understanding of this or any other issue. From that, I extract, polish, and sometimes destroy my own opinion."
Note: IPCC is the Intergovernmental Panel on Climate Change, AGU is the American Geophysical Union.

Extension:

1. Divide students into pro/con teams and conduct a debate based on the evidence presented by the students.
2. Conduct Socratic questioning exercise (resource attached) focusing on narrowed topic such as: If increased levels of CO_2 are affecting temperature change globally.
3. Create a matrix of evidence sited by both opinions about the cause and nature of global climate change. This matrix should not only align opposing viewpoints, but it should also identify points which one side makes that the other opinion omits or does not consider as relevant. This procedure could lead to further discussion about the nature of evidence submitted to support various ideas on the topic.

Homework: Research events referenced in articles such as "Little Ice Age" or "Dickens Winters." Report to class concerning the relevance of such events to the discussion of global climate change. The Climate Change Debate article provides perspective that discussion is not new.

Related Web Sites:
NOVA website has a graph that provides a variety of information on data found in ice cores.
http://www.pbs.org/wgbh/nova/warnings/stories/icecore.html
CO_2 Now website: http://co2now.org/
Articles on fossil record and information. Heib: http://www.geocraft.com/WVFossils/Articles1.html
Hydrogen Now journal: http://www.hydrogen.co.uk/h2_now/journal/articles/2_global_warming.htm
UCSD article: http://earthguide.ucsd.edu/virtualmuseum/climatechange2/07_1.shtml
EPA site with tons of definitions: http://www.epa.gov/climatechange/
www.thirteen.org/edonline/lessons/global/index/html
www.lessonplanet.com
wupcenter.nntu.edu/education/global_climate_change/lesson_plans.htm
www.nationalgreenweek.com/curricula/high-school-green-teams/climate-change-curricula.html
www.climatechangenorth.ca
serc.carlton.edu/NAGTWorkshops/climatechange
www.cln.org/themes/global_warming.html
climatechangeeducation.org
www.scinceinschool.org
apps1.eere.energy.gov/education/lessonplans/plan.cfm/lpid=253
http://icecap.us/index.php
http://media.kusi.clickability.com/documents/Comments+on+Global+Warming02.pdf

Student Reading Guidelines

1. List topic.

2. List unfamiliar vocabulary.

3. What are important pieces of information that you gained from reading and discuss the article with your group?

4. What proof in support of the hypothesis did the author offer?

5. Did the author express his/her opinion in the article?

6. Is the article opinion or data backed?

7. Did the article leave you with any questions?

Recognizing Propaganda Techniques and Errors of Faulty Logic

Propaganda Techniques

What are Propaganda Techniques? They are the methods and approaches used to spread ideas that further a cause - a political, commercial, religious, or civil cause.

Why are they used? To manipulate the readers' or viewers' reason and emotions; to persuade you to believe in something or someone, buy an item, or vote a certain way.

What are the most commonly used propaganda techniques? See which of the ten most common types of propaganda techniques you already know.

Types

Name calling: This techniques consists of attaching a negative label to a person or a thing. People engage in this type of behavior when they are trying to avoid supporting their own opinion with facts. Rather than explain what they believe in, they prefer to try to tear their opponent down.

Glittering Generalities: This technique uses important-sounding "glad words" that have little or no real meaning. These words are used in general statements that cannot be proved or disproved. Words like "good," "honest," "fair," and "best" are examples of "glad" words.

Transfer: In this technique, an attempt is made to transfer the prestige of a positive symbol to a person or an idea. For example, using the American flag as a backdrop for a political event makes the implication that the event is patriotic in the best interest of the U.S.

False Analogy: In this technique, two things that may or may not really be similar are portrayed as being similar. When examining the comparison, you must ask yourself how similar the items are. In most false analogies, there is simply not enough evidence available to support the comparison.

Testimonial: This technique is easy to understand. It is when "big name" personalities are used to endorse a product. Whenever you see someone famous endorsing a product, ask yourself how much that person knows about the product, and what he or she stands to gain by promoting it.

Plain Folks: This technique uses a folksy approach to convince us to support someone or something. These ads depict people with ordinary looks doing ordinary activities.

Card Stacking: This term comes from stacking a deck of cards in your favor. Card stacking is used to slant a message. Key words or unfavorable statistics may be omitted in an ad or commercial, leading to a series of half-truths. Keep in mind that an advertiser is under no obligation "to give the truth, the whole truth, and nothing but the truth."

Bandwagon: The bandwagon approach encourages you to think that because everyone else is doing something, you should do it too, or you'll be left out. The technique embodies a "keeping up with the Jones" philosophy.

Either/or fallacy: This technique is also called black-and-white thinking because only two choices are given. You are either for something or against it; there is no middle ground or shades of gray. It is used to polarize issues, and negates all attempts to find a common ground.

Faulty Cause and Effect: This technique suggests that because B follows A, A must cause B. Remember, just because two events or two sets of data are related does not necessarily mean that one caused the other to happen. It is important to evaluate data carefully before jumping to a wrong conclusion.

Errors of Faulty Logic

Contradiction: Information is presented that is in direct opposition to other information within the same argument. **Example**: If someone stated that schools were overstaffed, then later argued for the necessity of more counselors, that person would be guilty of contradiction.

Accident: Someone fails to recognize (or conceals the fact) that an argument is based on an exception to the rule. **Example**: By using selected scholar-athletes as the norm, one could argue that larger sports programs in schools were vital to improving academic performance of all students.

False Cause: A temporal order of events is confused with causality; or, someone oversimplifies a complex causal network. **Example**: Stating that poor performance in schools is caused by poverty; poverty certainly contributes to poor academic performance but it is not the only factor.

Begging the Question: A person makes a claim then argues for it by advancing grounds whose meaning is simply equivalent to that of the original claim. This is also called circular reasoning. **Example**: Someone argues that schools should continue to have textbooks read from cover to cover because, otherwise, students would not be well-educated. When asked to define what well-educated means, the person says, knowing what is in the textbooks.

Evading the Issue: Someone sidesteps an issue by changing the topic. **Example**: When asked to say whether or not the presence of homosexuals in the army could be a disruptive force, a speaker presents examples of homosexuals winning combat medals for bravery.

Arguing from Ignorance: Someone argues that a claim is justified simply because its opposite cannot be proven. **Example**: A person argues that voucher programs will not harm schools, since no one has ever proven that vouchers have harmed schools.

Composition and Division: Composition involves an assertion about a whole that is true of its parts. Division is the opposite: an assertion about all of the parts that is true about the whole. **Example**: When a school system holds up its above-average scores and claims that its students are superior, it is committing the fallacy of division. Overall, scores may be higher but that does not prove all students are performing at that level. Likewise, when the military points to the promiscuous behavior of some homosexuals, it is committing the fallacy of composition; the behavior of some cannot serve as proof of the behavior of all homosexuals.

Errors of Attack

Poisoning the Well: A person is so committed to a position that he/she explains away absolutely everything others offer in opposition. **Example**: Almost every proponent and opponent on the ban on gays in the military commits this error.

Ad Hominem: A person rejects a claim on the basis of derogatory facts (real or alleged) about the person making the claim. **Example**: Someone rejects former President Clinton's reasons for lifting the ban on gays in the military because of Mr. Clinton's draft record.

Appealing to Force: Someone uses threats to establish the validity of the claim. **Example**: Opponents of year-round school threaten to keep their children out of school during the summer months.

Errors of Weak Reference

Appeal to Authority: Authority is evoked as the last word on an issue. **Example**: Someone uses the Bible as the basis for his arguments against specific school reform issues.

Appeal to the People: Someone attempts to justify a claim on the basis of popularity. **Example**: Opponents of year-round school claim that students would hate it.

Appeal to Emotion: An emotion-laden sob story is used as proof for a claim. **Example**: A politician uses a sad story of a child being killed in a drive-by shooting to gain support for a year-round school measure.

Synopsis of Articles

Synopsis of articles for Day 1

1. Are Carbon Dioxide and Fossil Fuels Responsible for Global Warming? by John Coleman. This is a chapter from a paper Mr. Coleman posted on a website which denies that global climate change is occurring. (http://media.kusi.clickability.com/documents/Comments+on+Global+Warming02.pdf). Mr. Coleman is a meteorologist and his key points are:
   - CO_2 is not a pollutant and occurs naturally.
   - Levels of atmospheric CO_2 have naturally varied over time.
   - Human activity resulting in CO_2 output is not related to global temperature change.
   - CO_2 needs to be controlled, but this is not an extreme emergency.
   - Sun spots (solar activity) have more of an effect on global climate than atmospheric CO_2.

2. What the World Needs to Watch from the CO_2 Now website at: http://co2now.org/. This website is updated monthly from atmospheric CO_2 data collected from Mauna Loa Observatory. The website states that CO_2 is the direct cause of global warming. There are only years, not decades to resolve the problem. The article states that the upper safety limit for atmospheric CO_2 is 350 parts per million (ppm). Atmospheric CO_2 levels have stayed higher than 350 ppm since early 1988.

Synopsis of articles for Day 2

3. Paleoclimatology: The Ice Core Record. This article provides information as to how and what data can be obtained from ice core studies. This article provides reasoning behind this data collection.

4. Stories in the Ice. A concise, easy-to-read account of how and what data can be collected from ice sheets.

5. Ice Core Evidence of Human Impact on CO_2 In Air. This article discusses CO_2 evidence in ice. It does indicate a correlation between raised CO_2 and temperature levels.

6. Carbon Dioxide Over Time. This articles discusses the historical role of plate tectonics and the role of atmospheric CO_2 in atmosphere. (This is an advanced reading article in terms of vocabulary and science.)

7. Accelerated Global Warming & Atmospheric CO_2. This article provides a mathematical model for how much CO_2 is currently being put into the atmosphere and extrapolates amounts at the present rate. The article relates impact of tropical forests on the equation.

8. What is a Carbon Sink? This article provides a background for understanding the absorption and storage of CO_2.

9. Explaining Rapid Climate Change: Tales from the Ice. This article discusses data showing CO_2 levels in relation to global temperature.

10. Paleoclimatology: Written in Earth. This article discusses data used to understand ice ages.

11. Paleoclimatology: Explaining the Evidence. This article discusses the Milankovitch theory in an introductory manner.

12. Climate Change: Research suggests it is not a swindle: This article provides a commentary on a study resulting in evidence that sun spots are not major factors in global climate.

13. The Carboniferous: This article offers an explanation of fossil evidence of a period in the Earth's history during which CO_2 levels were extremely high. This period is referred to frequently in articles.

14. Climate and the Carboniferous Period. This article compares current CO_2 data with fossil evidence from the Carboniferous with a conclusion that CO_2 amounts do not play a significant role in climate change. The article takes plate tectonics into consideration. (This is a longer article which is very encompassing. Advanced.)

15. Two-Mile-Deep Antarctic Ice Core Reveals Stupidity of AGW Catastrophism: This article discusses the results of data reported at a scientific conference. The article renounces CO_2 levels as responsible for climate change and proposes 'iron dust' as a major factor. (Only mention of this component in any of this collection of articles.)

16. Sea Ice At Lowest Level In 800 Years Near Greenland: Data report.

17. Chilean Glaciers Melting at Unprecedented Rates. Data report.

18. <u>Media attacked for climate porn and chaotic world of climate truth</u>: Two separate articles each discussing negative impact of hyperbolic media coverage of the climate change issue. (No science or data is referenced.)

19. <u>The Climate Change Debate</u>: A debate over climate change that has occurred over a long period of time. (Suggested homework reading.)

Are Carbon Dioxide and Fossil Fuels Responsible for Global Warming?

In the Al Gore movie, "An Inconvenient Truth", we see the famous hockey stick chart as proof that global warming is sweeping the Earth. Time and research has taken its toll on that chart. It is no longer regarded as accurate. In fact, it has been quietly dropped by the United Nations Intergovernmental Panel on Climate Change. Now the global warming advocates point to the increase in carbon dioxide in the atmosphere. It's up, way up; no argument about that. Our modern civilization, powered by fossil fuels, sends tons of carbon dioxide (CO_2) in the atmosphere as we generate electricity to power our lights, furnaces and air conditioners, computers, television sets, cell phones and i-pods and as we drive gasoline powered cars and fly in airplanes. Our modern standard of living is absolutely linked to CO_2. And it has increased in our atmosphere from around 218 parts per million in 1900 to about 375 ppm today. You need to understand immediately that CO_2 is a naturally occurring trace element in our atmosphere. For one thing, we humans produce it every time we breathe. Plants and trees must have it grow. So CO_2 was already in our atmosphere before we discovered oil. CO_2 is not a pollutant.

The pollutants produced by burning fossil fuels have been largely controlled by catalytic converters, reformulated gasoline, smoke stack scrubbers and other improvements in ignition, fuel management and exhaust systems. Nonetheless, it is in our civilization's best interest to find ways to eliminate fossil fuels from our living within the next few generations. But, there is no climatic emergency from our use of them.

Now the really good news: The increase in our atmospheric carbon dioxide during the 20th and early 21st centuries has produced no deleterious effects upon Earth's weather and climate. There is absolutely no correlation between the increase in CO_2 and average worldwide or U.S. temperatures. And, predictions of harmful climatic effects due to future increases in hydrocarbon use and resulting increases in minor greenhouse gases such as CO_2 do not conform to current experimental knowledge or have any scientific basis. On the other hand, increased carbon dioxide has markedly increased plant growth. Forest growth and farm crop output per acre have grown proportionally with increased atmospheric CO_2 that is a key to photosynthesis in plants.

The average temperature of the Earth has varied within a range of about 3°C during the past 3,000 years. It is currently increasing as the Earth recovers from a period that is known as the Little Ice Age. Atmospheric temperature is regulated by the sun, which fluctuates in activity; by the greenhouse effect, which is largely caused by atmospheric water vapor (H_2O); and by other phenomena that are more poorly understood. While major greenhouse gas H_2O substantially warms the Earth, minor greenhouse gases such as CO_2 have little effect. The 6-fold increase in hydrocarbon use and CO_2 production since 1940 has had no noticeable effect on atmospheric temperatures.

Historically we can clearly see that hydrocarbon use does not correlate with temperature changes. Temperature rose for a century before significant hydrocarbon use. Temperature rose between 1910 and 1940, while hydrocarbon use was almost unchanged. Temperature then fell between 1940 and 1972, while hydrocarbon use rose by 330%.

The historical record does not contain any report of global warming catastrophes, even though temperatures have been higher than they are now during much of the last three millennia. An increase in CO_2 is said to increase the radiative effect of the greenhouse gases in the atmosphere. But, how and in which direction does the atmosphere respond? Hypotheses about this response differ. Without the water vapor greenhouse effect, the Earth would be about 14°C cooler. The radiative contribution of doubling atmospheric CO_2 is minor, but this radiative greenhouse effect is treated quite differently by different climate hypotheses. The hypotheses that the United Nations Intergovernmental Panel on Climate Change has chosen to adopt predicts that the effect of CO_2 is amplified by the atmosphere, especially by water vapor, to produce a large temperature increase. Other hypotheses, predict the opposite—that the atmospheric response will counteract the CO_2 increase and result in insignificant changes in global temperature. The experimental evidence favors hypothesis 2. While CO_2 has increased substantially, its effect on temperature has been so slight that it has not been experimentally detected.

Roger Revelle of Scripps Institution of Oceanography, Harvard University and University of California, San Diego, was the co-author of the seminal 1957 paper that demonstrated that fossil fuels had increased carbon dioxide levels in the air. Under his leadership, the President's Science Advisory Committee Panel on Environment Pollution in 1965 published the first authoritative U.S. government report in which carbon dioxide from fossil fuels was officially recognized as a potential global problem. He was the author of the influential 1982 Scientific American article that elevated global warming on to the public agenda. For being the grandfather of the greenhouse effect, as he put it, he was awarded the National Medal of Science by the first President Bush.

However, he understood that the impact of carbon dioxide in the atmosphere was a tricky issue. In a letter he wrote in 1988 shortly before he died of a heart attack, he said that, "Most scientists familiar with the subject are not yet willing to bet that the climate this year is the result of greenhouse warming. As you very well know, climate is highly variable from year to year and the causes of these variations are not at all well understood. My own personal belief is that we should wait another 10 or 20 years to really be convinced that the greenhouse is going to be important for human beings, in both positive and negative ways." A few days later, in another letter he cautioned "we should be careful not to arouse too much alarm until the rate and amount of warming becomes clearer." Today we know his caution was merited. CO_2 is not a pollutant. It is a trace element essential to plant growth and a natural product of human breathing and many other normal processes. Yes, it is way up in the atmosphere; but still it is only 37 of every 100,000 atmospheric molecules. Despite all the shouting by global warming advocates that CO_2, carbon dioxide, is the smoking gun of global warming, there is absolutely no proven evidence that CO_2 has affected temperatures and plenty of evidence it has not.

So if atmospheric CO_2 and other greenhouse gases are not causing the Earth to warm up, what is? **The answer seems to be Sun cycles.**

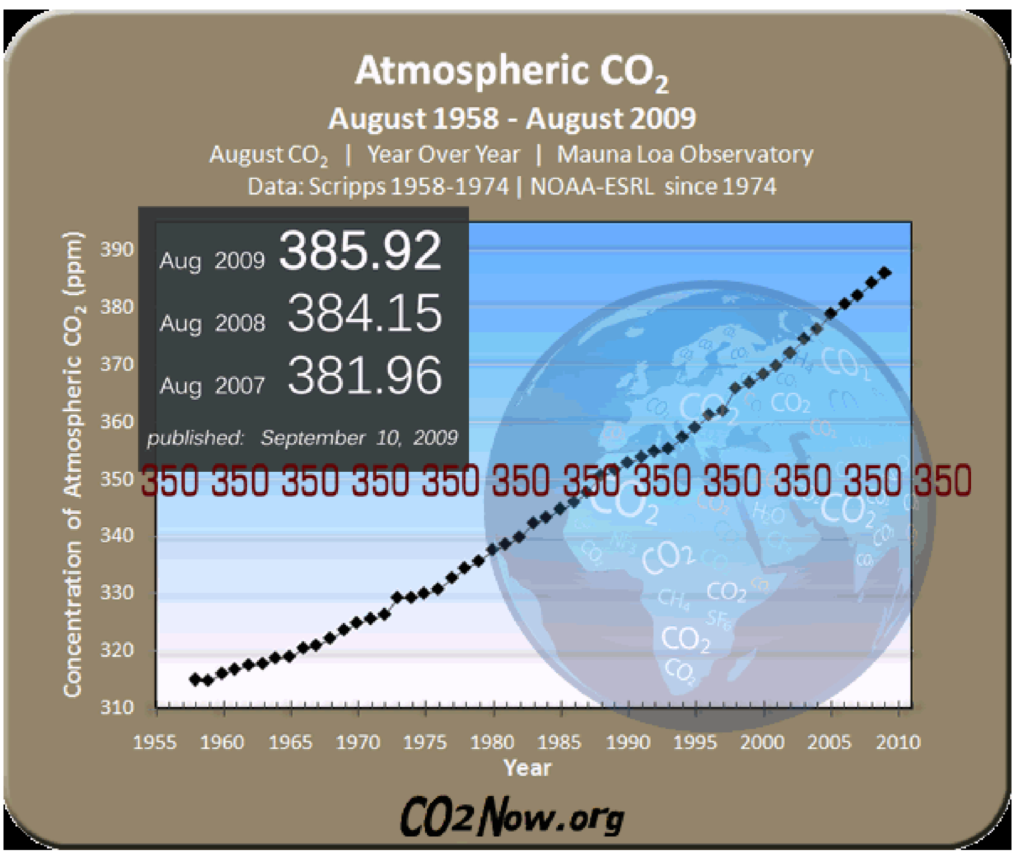
Source: John Coleman, November 23, 2007
http://media.kusi.clickability.com/documents/Comments+on+Global+Warming02.pdf

What the World Needs to Watch

Current Data for Atmospheric CO_2

The world's most current data for atmospheric CO_2 is from measurements at the Mauna Loa Observatory in Hawaii. These high-precision measurements were started by Dave Keeling (shown in the photo) in March 1958. Today, the monthly average concentration of CO_2 in the atmosphere is published by the National Oceanic and Atmospheric Administration (NOAA) within a week after each month ends. The source data is organized into a table and republished at CO_2Now.org so more people can see the latest CO_2 level and the important CO_2 trend. The table includes the full Mauna Loa instrument record for atmospheric CO_2.

Global warming is mainly the result of CO_2 levels rising in the Earth's atmosphere. Both atmospheric CO_2 and climate change are accelerating. Climate scientists say we have years, not decades, to stabilize CO_2 and other greenhouse gases. To help the world succeed, CO_2Now.org makes it easy to see the most current CO_2 level and what it means. So, use this site and keep an eye on CO_2. Invite others to do the same. Then we can do more to send CO_2 in the right direction.



385.92 ppm
Atmospheric CO2 for August 2009

CO_2 Data Set: Original data file created by NOAA on Monday May 11, 2009 (08:59:46).

Measuring Location: Mauna Loa Observatory, Hawaii

Data Source: Earth Systems Research Laboratory (ESRL) / National Oceanic and Atmospheric Administration (NOAA)

Why is CO_2 significant? Carbon dioxide is the chief greenhouse gas that results from human activities and causes global warming and climate change. To see whether enough is being done at the moment to solve these global problems, there is no single indicator as complete and current as the monthly updates for atmospheric CO_2 from the Mauna Loa Observatory.

What is the current trend? At least since the 1958 start of atmospheric CO_2 measurements with high-precision instruments, the rate of increase in atmospheric carbon dioxide concentration has accelerated from decade to decade. The latest atmospheric CO_2 data is consistent with a continuation of this long-standing trend.

What level is safe? The upper safety limit for atmospheric CO_2 is 350 parts per million (ppm). Atmospheric CO_2 levels have stayed higher than 350 ppm since early 1988.

Source: CO_2 Now website:
http://co2now.org/index.php/Current-CO2/CO2-Now/index.php?option=com_frontpage&Itemid=1

Current Data for Atmospheric CO_2

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1958			315.71	317.45	317.50	317.11	315.86	314.93	313.20	312.61	313.33	314.67	
1959	315.62	316.38	316.71	317.72	318.29	318.16	316.55	314.80	313.84	313.26	314.80	315.59	**315.98**
1960	316.43	316.97	317.58	319.02	320.02	319.59	318.18	315.91	314.16	313.83	315.00	316.19	**316.91**
1961	316.93	317.70	318.54	319.48	320.58	319.77	318.58	316.79	314.80	315.38	316.10	317.01	**317.64**
1962	317.94	318.55	319.68	320.63	321.01	320.55	319.58	317.40	316.26	315.42	316.69	317.70	**318.45**
1963	318.74	319.08	319.86	321.39	322.24	321.47	319.74	317.77	316.21	315.99	317.12	318.31	**318.99**
1964	319.57	320.11	320.76	321.79	322.24	321.89	320.44	318.70	316.70	316.79	317.79	318.71	**319.62**
1965	319.44	320.44	320.89	322.13	322.16	321.87	321.39	318.80	317.81	317.30	318.87	319.42	**320.04**
1966	320.62	321.59	322.39	323.87	324.01	323.75	322.40	320.37	318.64	318.10	319.78	321.08	**321.38**
1967	322.06	322.50	323.04	324.42	325.00	324.09	322.55	320.92	319.31	319.31	320.72	321.96	**322.16**
1968	322.57	323.15	323.89	325.02	325.57	325.36	324.14	322.03	320.41	320.25	321.31	322.84	**323.04**
1969	324.00	324.42	325.64	326.66	327.34	326.76	325.88	323.67	322.38	321.78	322.85	324.12	**324.62**
1970	325.03	325.99	326.87	328.14	328.07	327.66	326.35	324.69	323.10	323.16	323.98	325.13	**325.68**
1971	326.17	326.68	327.18	327.78	328.92	328.57	327.34	325.46	323.36	323.56	324.80	326.01	**326.32**
1972	326.77	327.63	327.75	329.72	330.07	329.09	328.05	326.32	324.93	325.06	326.50	327.55	**327.45**
1973	328.55	329.56	330.30	331.50	332.48	332.07	330.87	329.31	327.51	327.18	328.16	328.64	**329.68**
1974	329.35	330.71	331.48	332.65	333.15	332.13	330.99	329.17	327.41	327.21	328.34	329.50	**330.17**
1975	330.68	331.41	331.85	333.29	333.91	333.40	331.74	329.88	328.57	328.35	329.33	330.55	**331.08**
1976	331.66	332.75	333.46	334.78	334.79	334.05	332.95	330.64	328.96	328.77	330.18	331.65	**332.05**
1977	332.69	333.23	334.97	336.03	336.82	336.10	334.79	332.53	331.19	331.21	332.35	333.47	**333.78**
1978	335.09	335.26	336.62	337.77	338.00	337.98	336.48	334.37	332.33	332.40	333.76	334.83	**335.41**
1979	336.21	336.64	338.13	338.96	339.02	339.20	337.60	335.56	333.93	334.12	335.26	336.78	**336.78**
1980	337.80	338.28	340.04	340.86	341.47	341.26	339.34	337.45	336.10	336.05	337.21	338.29	**338.68**
1981	339.36	340.51	341.57	342.56	343.01	342.51	340.71	338.51	336.96	337.13	338.58	339.91	**340.11**
1982	340.92	341.69	342.88	343.83	344.30	343.42	341.85	339.82	337.98	338.09	339.24	340.67	**341.22**
1983	341.42	342.67	343.45	345.08	345.76	345.33	343.93	342.08	340.00	340.12	341.35	342.89	**342.84**
1984	343.87	344.59	345.29	346.58	347.36	346.80	345.37	343.06	341.24	341.54	342.90	344.36	**344.41**
1985	345.08	345.89	347.49	348.02	348.75	348.19	346.49	344.70	343.04	342.92	344.22	345.61	**345.87**
1986	346.42	346.95	347.88	349.57	350.35	349.70	347.78	345.89	344.88	344.34	345.67	346.89	**347.19**
1987	348.20	348.55	349.56	351.12	351.84	351.45	349.77	347.62	346.37	346.48	347.80	349.03	**348.98**
1988	350.23	351.58	352.22	353.53	354.14	353.64	352.53	350.42	348.84	348.94	349.99	351.29	**351.45**
1989	352.72	353.10	353.64	355.43	355.70	355.11	353.79	351.42	349.83	350.10	351.26	352.66	**352.90**
1990	353.63	354.72	355.49	356.10	357.08	356.11	354.67	352.67	351.05	351.36	352.81	354.21	**354.16**

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1991	354.87	355.67	357.00	358.40	359.00	357.99	355.96	353.78	352.20	352.22	353.70	354.98	**355.48**
1992	356.08	356.84	357.73	358.91	359.45	359.19	356.72	354.77	352.80	353.21	354.15	355.39	**356.27**
1993	356.76	357.17	358.26	359.17	360.07	359.41	357.36	355.29	353.96	354.03	355.27	356.70	**356.95**
1994	358.05	358.80	359.67	361.13	361.48	360.60	359.20	357.23	355.42	355.89	357.41	358.74	**358.64**
1995	359.73	360.61	361.60	363.05	363.62	363.03	361.55	358.94	357.93	357.80	359.22	360.42	**360.62**
1996	361.83	362.94	363.91	364.28	364.93	364.70	363.31	361.15	359.41	359.34	360.62	361.96	**362.36**
1997	362.81	363.87	364.25	366.02	366.47	365.36	364.10	361.89	360.05	360.49	362.21	364.12	**363.47**
1998	365.00	365.82	366.95	368.42	369.33	368.78	367.59	365.81	363.83	364.18	365.36	366.87	**366.50**
1999	367.97	368.83	369.46	370.77	370.66	370.10	369.10	366.70	364.61	365.17	366.51	367.86	**368.14**
2000	369.07	369.32	370.38	371.63	371.32	371.51	369.69	368.18	366.87	366.94	368.27	369.62	**369.40**
2001	370.47	371.44	372.39	373.32	373.77	373.13	371.51	369.59	368.12	368.38	369.64	371.11	**371.07**
2002	372.38	373.08	373.87	374.93	375.58	375.44	373.91	371.77	370.72	370.50	372.19	373.71	**373.17**
2003	374.92	375.63	376.51	377.75	378.54	378.21	376.65	374.28	373.12	373.10	374.67	375.97	**375.78**
2004	377.03	377.87	378.88	380.42	380.62	379.66	377.48	376.07	374.10	374.47	376.15	377.51	**377.52**
2005	378.43	379.70	380.91	382.20	382.45	382.14	380.60	378.60	376.72	376.98	378.29	380.07	**379.76**
2006	381.36	382.19	382.65	384.65	384.94	384.01	382.15	380.33	378.81	379.06	380.17	381.85	**381.85**
2007	382.89	383.77	384.42	386.36	386.53	386.01	384.45	381.96	380.81	381.09	382.37	383.84	**383.71**
2008	385.42	385.72	385.96	387.18	388.50	387.88	386.38	384.15	383.07	382.98	384.11	385.54	**385.57**
2009	386.92	387.42	388.79	389.47									

Paleoclimatology: The Ice Core Record

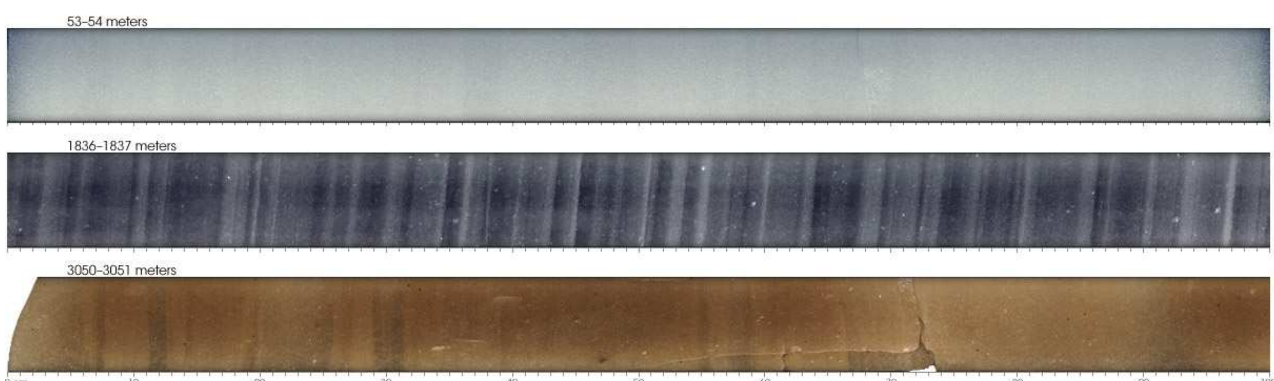
Richard Alley might have envied paleoceanographer Jerry McManus' warm, ship-board lab. One of the researchers in the Greenland Ice Sheet Project 2 (GISP2), Alley huddled in a narrow lab cut into the Greenland Ice Sheet, where the temperature stayed at a comfortable twenty below F. He wrote in his book about his research, *The Two-Mile Time Machine.* An assembly line of science equipment lined the twenty-foot deep trench that served as a makeshift lab. For six weeks every summer between 1989 and 1993, Alley and other scientists pushed columns of ice along the science assembly line, labeling and analyzing the snow for information about past climate, then packaging it to be sent for further analysis and cold storage at the National Ice Core Laboratory in Denver, Colorado. Nearby, a specially built drill bored into the thick ice sheet twenty-four hours a day under the perpetual Arctic sun. Essentially a sharp-ened pipe rotating on a long, loose cable, the drill pulled up cores of ice from which Alley and others would glean climate information.

Ice sheets contain a record of hundreds of thousands of years of past climate, trapped in the ancient snow. Scientists recover this climate history by drilling cores in the ice, some of them over 3,500 meters (11,000 feet) deep. These photographs show experimental drilling on the Greenland Ice Cap in summer 2005.

Throughout each year, layers of snow fall over the ice sheets in Greenland and Antarctica. Each layer of snow is different in chemistry and texture, summer snow differing from winter snow. Summer brings 24 hours of sunlight to the polar regions, and the top layer of the snow changes in texture—not melting exactly, but changing enough to be different from the snow it covers. The season turns cold and dark again, and more snow falls, forming the next layer of snow. Each layer gives scientists a treasure trove of information about the climate each year. Like marine sediment cores, an ice core provides a vertical timeline of past climates stored in ice sheets and mountain glaciers.

Blue light filtered through the wall of an Antarctic snow pit illuminates "Tuck," the mascot for Tuckahoe Elementary School in Henrico County, Virginia. The furry white owl accompanied scientists to Antarctica as part of an educational program. In the wall of the pit, dark and light bands of slowly compacted snow distinguish snow deposited in the winter from snow deposited in the summer.

The seasonal snow layers are easiest to see in snow pits, writes Alley, the Evan Pugh Professor in the Environment Institute and Department of Geosciences at Pennsylvania State University. To see the layers, scientists dig two pits separated by a thin wall of snow. One pit is covered, and the other is left open to sunlight. By standing in the covered pit, scientists can study the annual snow layers in the snow wall as the sunlight filters through the other side. "I have stood in snow pits with dozens of people—drillers, journalists, and others—and so far, every visitor has been impressed. The snow is blue, something like the blue seen by deep sea divers, an indescribable, almost achingly beautiful blue," writes Alley. "The next thing most people notice is the layering."

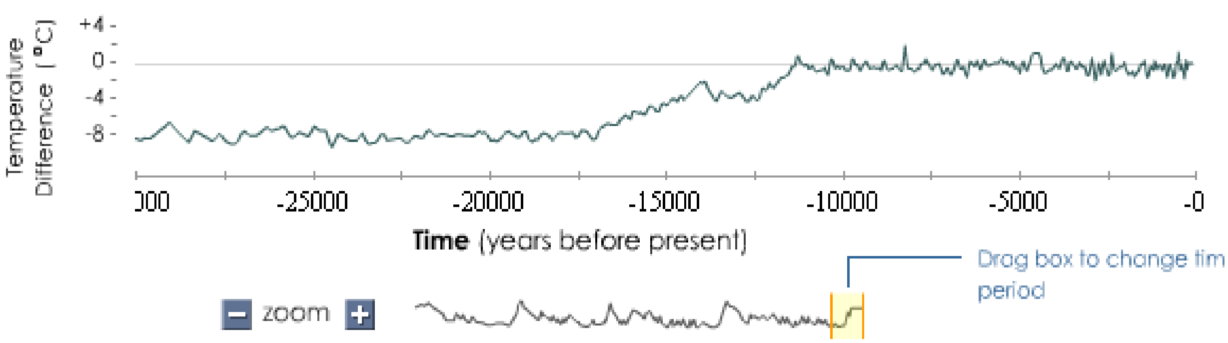


The gradually increasing weight of overlying layers compresses deeply buried snow into ice, but annual bands remain. Relatively young and shallow snow becomes packed into coarse and granular crystals called firn (top: 53 meters deep). Older and deeper snow is compacted further (middle: 1,836 meters). At the bottom of a core (lower: 3,050 meters), rocks, sand, and silt discolor the ice.

To pry climate clues out of the ice, scientists began to drill long cores out of the ice sheets in Greenland and Antarctica in the late 1960s. By the time Alley and the GISP2 project finished in the early 1990s, they had pulled a nearly 2-mile-long core (3,053.44 meters) from the Greenland ice sheet, providing a record of at least the past 110,000 years. Even older records going back about 750,000 years have come out of Antarctica. Scientists have also taken cores from thick mountain glaciers in places such as the Andes Mountains in Peru and Bolivia, Mount Kilimanjaro in Tanzania, and the Himalayas in Asia.

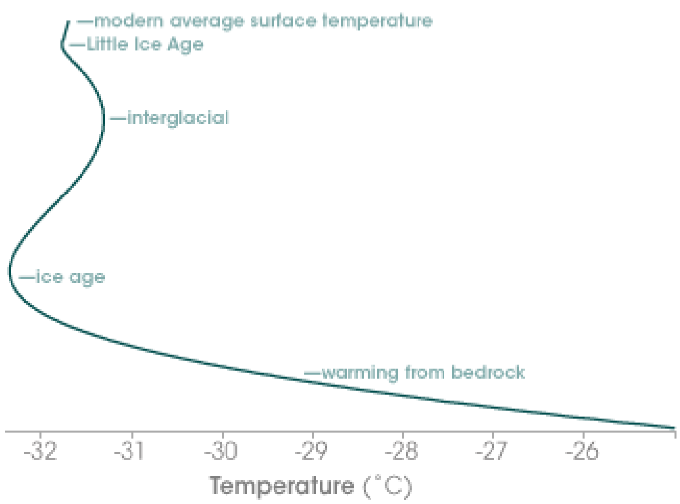
Researchers retrieve climate records from mountain glaciers in addition to the records from polar ice sheets. Drilling sites around the world help distinguish trends in local climate from trends in global climate. This drilling station is located at an elevation of 6,425 meters (21,080 feet) on the summit of Nevado Coropuna in the Peruvian Andes.

The ice cores can provide an annual record of temperature, precipitation, atmospheric composition, volcanic activity, and wind patterns. In a general sense, the thickness of each annual layer tells how much snow accumulated at that location during the year. Differences in cores taken from the same area can reveal local wind patterns by showing where the snow drifted. More importantly, the make-up of the snow itself can tell scientists about past temperatures. As with marine fossils, the ratio of oxygen isotopes in the snow reveals temperature, though in this case, the ratio tells how cold the air was at the time the snow fell. In snow, colder temperatures result in higher concentrations of light oxygen.



The ice core recovered from Vostok, Antarctica, records over 400,000 years of climate history. This interactive graph shows temperature measurements derived from the core. Temperatures equal to or greater than the recent average (gray line) delineate interglacial periods, while colder temperatures indicate ice ages.

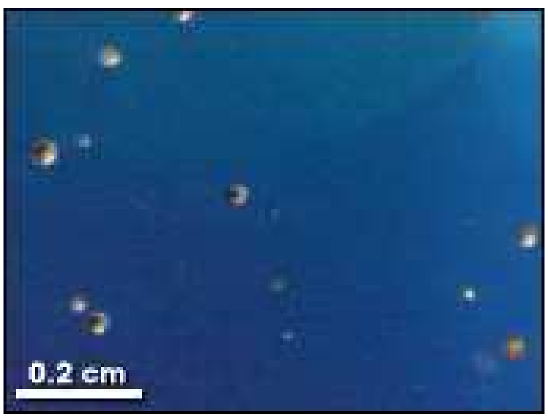
Scientists can confirm these chemistry-based temperature measurements by observing the temperature of the ice sheet directly. The ice sheet's thickness makes its temperature much more resistant to change than the six inches of snow that might fall on your driveway during a winter snowstorm. As Alley explained to the Earth Observatory, the ice sheet can be compared to a frozen roast that is put directly into the oven. The outside heats up quickly, but the center remains cold, close to the temperature of the freezer, for a long time. Similarly, the ice sheet has warmed somewhat since the Ice Age, but not completely. The top has warmed as global temperatures have warmed, while the bottom has been warmed by heat flow from deep inside the Earth. But in the middle of an ice sheet, the ice remains close to the Ice Age temperatures at which it formed. "Because we understand how heat moves in ice, [and] we know how cold the ice is today, we can calculate how cold the ice was during the Ice Age," says Alley.



Scientists measure the temperature of an ice sheet directly by lowering a thermometer into the borehole that was drilled to retrieve the ice core. Like an insulated thermos, snow and ice preserve the temperature of each successive layer of snow, which reflects general atmospheric temperatures when the layer accumulated. Close to the surface of the bedrock, the lowest layers of the ice are warmed by the heat of the Earth. These physical temperature measurements help calibrate the temperature record scientists obtain from oxygen isotopes. (Graph based on data provided by Gary Clow, United States Geological Survey)

When scientists lower an ultra-precise thermometer into a hole in the ice, they can detect the temperature variations that have occurred since the Ice Age. The near-surface ice temperature, like the atmosphere today, is warm, and then the temperature drops in the layers formed roughly between AD 1450 and 1850, a period known as the Little Ice Age, one of several cold snaps that briefly interrupted the overall warming trend ongoing since the end of the Ice Age. As the thermometer goes deeper into the ice sheet, the temperature warms again, and then plummets to the temperatures indicative of the Ice Age. Finally, the bottom layers of the ice sheet are warmed by heat coming from the Earth. These directly measured temperatures represent a rough average—a record of trends, not variable, daily temperatures—but climatologists can compare the thermometer temperatures with the oxygen isotope record as a way to calibrate those results.

As valuable as the temperature record may be, the real treasure buried in the ice is a record of the atmosphere's characteristics. When snow forms, it crystallizes around tiny particles in the atmosphere, which fall to the ground with the snow. The type and amount of trapped particles, such as dust, volcanic ash, smoke, or pollen, tell scientists about the climate and environmental conditions when the snow formed. As the snow settles on the ice, air fills the space between the ice crystals. When the snow gets packed down by subsequent layers, the space between the crystals is eventually sealed off, trapping a small sample of the atmosphere in newly formed ice. These bubbles tell scientists what gases were in the atmosphere, and based on the bubble's location in the ice core, what the climate was at the time it was sealed. Records of methane levels, for example, indicate how much of the Earth wetlands covered because the abundance of life in wetlands gives rise to anaerobic bacteria that release methane as they decompose organic material. Scientists can also use the ice cores to correlate the concentration of carbon dioxide in the atmosphere with climate change—a measurement that has emphasized the role of carbon dioxide in global warming.



Air bubbles trapped in the ice cores provide a record of past atmospheric composition. Ice core records prove that current levels of carbon dioxide and methane, both important greenhouse gases, are higher than any previous level in the past 400,000 years.

Finally, anything that settles on the ice tends to remain fixed in the layer it landed on. Of particular interest are wind-blown dust and volcanic ash. As with dust found in sea sediments, dust in ice can be analyzed chemically to find out where it came from. The amount and location of dust tells scientists about wind patterns and strength at the time the particles were deposited. Volcanic ash can also indicate wind patterns. Additionally, volcanoes pump sulfates into the atmosphere, and these tiny particles also end up in the ice cores. This evidence is important because volcanic activity can contribute to climate change, and the ash layers can often be dated to help calibrate the timeline in the layers of ice.

Ash from volcanic eruptions becomes trapped in ice sheets along with snow and dust. Scientists use the volcanic ash found in ice cores to date the cores and to estimate the intensity of past volcanic activity. This satellite image shows black ash from the eruption of Hekla on top of bright white Icelandic snow on February 29, 2000.

Though ice cores have proven to be one of the most valuable climate records to date, they only provide direct evidence about temperature and rainfall where ice still exists, though they hint at global conditions. Marine sediment cores cover a broader area—nearly 70 percent of the Earth is covered in oceans—but they only give tiny hints about the climate over the land. Soil and rocks on the Earth's surface reveal the advance and retreat of glaciers over the land surface, and fossilized pollen traces out rough boundaries of where the climate conditions were right for different species of plants and trees to live. Unique water and rock formations in caves harbor a climate record of their own. To understand the Earth's climate history, scientists must bring together all of these scattered threads into a single, seamless story.

Source: Holli Riebeek, December 19, 2005
http://earthobservatory.nasa.gov/Features/Paleoclimatology_IceCores/

Links:
- Byrd Polar Research Center
- NOAA Paleoclimatology Program

Stories in the Ice

Nature's Time Machine

How would you like to have a time machine that could take you back anywhere over the past 300,000 years? You could see what the world was like when ice sheets a thousand feet thick blanketed Canada and northern Europe, or when the Indonesian volcano Toba blew its top in the largest volcanic eruption of the last half million years.

Well, scientists have such a time machine. It's called an ice core. Scientists collect ice cores by driving a hollow tube deep into the miles-thick ice sheets of Antarctica and Greenland (and in glaciers elsewhere). The long cylinders of ancient ice that they retrieve provide a dazzlingly detailed record of what was happening in the world over the past several ice ages. That's because each layer of ice in a core corresponds to a single year—or sometimes even a single season—and most everything that fell in the snow that year remains behind, including wind-blown dust, ash, atmospheric gases, even radioactivity.

Indeed, fallout from the Chernobyl nuclear accident has turned up in ice cores, as has dust from violent desert storms countless millennia ago. Collectively, these frozen archives give scientists unprecedented views of global climate over the eons. More important, the records allow researchers to predict the impact of significant events—from volcanic eruptions to global warming—that could strike us today.

Source: Peter Tyson, Online Producer, NOVA
http://www.pbs.org/wgbh/nova/warnings/stories/

Atmospheric Greenhouse Gases Affected by Human Activities

ppmv = Parts per million by volume

CO_2 Concentration

Year	ppmv
1958	314.80
1959	316.10
1960	317.00
1961	317.70
1962	318.60
1963	319.10
1964	319.40
1965	320.40
1966	321.10
1967	322.00
1968	322.80
1969	324.20
1970	325.50
1971	326.50
1972	327.60
1973	329.80
1974	330.40
1975	331.00
1976	332.10
1977	333.60
1978	335.20
1979	336.50
1980	338.40
1981	339.50
1982	340.80
1983	342.80
1984	344.30
1985	345.70
1986	346.90
1987	348.60
1988	351.20
1989	352.90
1990	354.20
1991	355.60
1992	356.40
1993	357.00
1994	358.90
1995	360.90
1996	362.60
1997	363.80
1998	366.60
1999	368.30

CO_2 Concentration
continued . . .

Year	ppmv
2000	369.50
2001	371.00
2002	373.10
2003	375.60
2004	377.40

Methane Concentration

Year	ppmv
1850	0.90
1879	0.93
1880	0.90
1892	0.88
1908	1.00
1917	1.00
1918	1.02
1927	1.03
1929	1.13
1940	1.12
1949	1.18
1950	1.20
1955	1.26
1956	1.30
1957	1.34
1958	1.35
1975	1.45
1976	1.47
1977	1.50
1978	1.52
1979	1.55
1980	1.56
1981	1.58
1982	1.60
1983	1.60
1984	1.61
1985	1.62
1986	1.63
1987	1.65
1988	1.67
1989	1.69
1990	1.72

CFC Production

Year	Amount
1955	100.00
1957	120.00
1959	140.00
1961	150.00
1963	150.00
1965	200.00
1967	225.00
1969	290.00
1971	320.00
1973	375.00
1975	350.00
1977	360.00
1979	330.00
1981	325.00
1983	320.00
1985	340.00
1987	300.00
1989	305.00
1991	310.00

Nitrous Oxide

Year	ppmv
1750	283.00
1760	283.50
1770	284.00
1780	284.00
1790	285.00
1800	285.50
1810	286.00
1820	286.50
1830	287.00
1840	287.50
1850	288.00
1860	288.50
1870	289.00
1880	289.50
1890	290.00
1900	291.00
1910	292.00
1920	292.50
1930	293.00
1940	294.00
1950	295.00
1960	297.00
1970	299.00
1980	305.00
1990	310.00

Ice Core Evidence of Human Impact on CO_2 in Air

NORWICH -- Air from the oldest ice core confirms human activity has increased the greenhouse gas carbon dioxide (CO_2) in the atmosphere to levels not seen for hundreds of thousands of years, scientists said on Monday.

Bubbles of air in the 800,000 year old ice, drilled in the Antarctic, show levels of CO_2 changing with the climate. But the present levels are out of the previous range.
"It is from air bubbles that we know for sure that carbon dioxide has increased by about 35% in the last 200 years," said Dr Eric Wolff of the British Antarctic Survey and the leader of the science team for the 10-nation European Project for Ice Coring in Antarctica. "Before the last 200 years, which man has been influencing, it was pretty steady," he added.

The natural level of CO_2 over most of the past 800,000 years has been 180-300 parts per million by volume (ppmv) of air. But today it is at 380 ppmv. "The scariest thing is that carbon dioxide today is not just out of the range of what happened in the last 650,000 years but already up 100% out of the range," Wolff said at the British Association Festival of Science in Norwich, eastern England. CO_2 was close to 280 ppmv from 1000 AD until 1800 and then it accelerated toward its present concentration. Wolff added that measurements of carbon isotopes showed the extra CO_2 coming from a fossil source, due to increased human activity.

The ice core record showed it used to take about 1,000 years for a CO_2 increase of 30 ppmv. It has raised by that much in the last 17 years alone. "We really are in a situation where something is happening that we don't have any analog for in our records. It is an experiment that we don't know the result of," he added. Professor Peter Smith, of the University of Nottingham in England, said the study showed more needed to be done. "There is an urgent need to find innovative technologies to reduce the impact we are having on our climate," he told the science conference.

Source: Reuters, September 4, 2006
http://www.planetark.com/dailynewsstory.cfm/newsid/37966/story.htm

Carbon Dioxide through Geologic Time

Introduction

Since the Earth's atmosphere is out of balance with the conditions expected from simple chemical equilibrium, it is very hard to say what precisely sets the level of the carbon dioxide content in the air throughout geologic time. While scientists are fairly certain that a 100 million years ago carbon dioxide values were many times higher than now, the exact value is in doubt. In very general terms, long-term reconstructions of atmospheric CO_2 levels going back in time show that 500 million years ago atmospheric CO_2 was some 20 times higher than present values. It dropped, then rose again some 200 million years ago to 4-5 times present levels--a period that saw the rise of giant fern forests--and then continued a slow decline until recent pre-industrial time.

Carbon Cycling, Plate Tectonics and Organic Matter Burial

Most scientists agree that carbon dioxide has decreased over the last 200 million years because of speeding up of the passage of carbon atoms from their volcanic sources into sediments. To lower the CO_2 content one needs fresh rocks to provide calcium, and it also helps to bury organic matter.

Fresh rocks are provided through plate collisions and mountain building, that is, uplift of land and a drop in sea level. On the whole, there has been a trend to make more mountains during the last 100 million years, and especially since the last 40 million years. This is seen in the strontium isotope content of marine carbonates. The type of strontium derived from igneous rocks on land has increased relative to the type of strontium from other sources.

Organic matter is buried in swamps (plant remains turn into coal) and in continental margins (marine algal remains become hydrocarbons). The climate cooled as the planet acquired mountain ranges (like the Himalayas) and as sea level dropped. Trade winds became more vigorous. Coastal upwelling of nutrients in coastal waters increased. Thus, more organic matter was buried along the coasts of continents. Also, an increase in the amount of mud from the rising mountains helped to bury the organic matter.

As time went on carbon dioxide was more readily turned into sedimentary carbon and the planet cooled some more. Methane hydrate could have formed on the sea floor, trapping methane and denying another source of carbon to the ocean-atmosphere system. (The exception might perhaps have been during sporadic release of this methane, followed by strange jumps in climate.)

Carbon Cycle and Computer Models

So many processes have to be considered in the carbon cycle that it is extremely difficult to keep them in mind, and impossible to calculate without building a computer model to simulate them. Scientists interested in the carbon cycle have built a number of such models over the years. Such models can have between 50 and 100 interacting equations describing all the different processes of the carbon cycle that are relevant to the problem of how carbon dioxide changes through geologic time.

To what extent should the answers generated from such models be trusted? Consider this: if there are a dozen processes which we need to understand, and we only grasp each process within an error of 20%, the sum-total of the error adds to more than 200%! That is, if we now state that the content of carbon dioxide in the air so many million years ago had to be X, the true answer could be anywhere between 3 times X (200% more than stated) and X divided by 3 (200% less). Even if we make the reasonable assumption that half of the errors will cancel, we still get roughly a factor of two error on either side of the uncertainty statement. Thus, at the present state of knowledge, computing the answers will get us ballpark estimates and overall trends but not much more. Now you can appreciate why the range of errors plotted in the figure above are so large.

Source: University of California, San Diego
http://earthguide.ucsd.edu/virtualmuseum/climatechange2/07_1.shtml

Accelerated Global Warming and Atmospheric CO_2 Emissions

An assessment of the likely increase of CO_2 in the atmosphere due to climate change and if the Amazon Rainforest ceases to be a CO_2 sink.

The CO_2 content of the atmosphere is usually expressed in parts per million (ppm) by weight and the use of fossil fuels is expressed as so many tons of carbon burned per year. At present the burning of fossil fuels releases 7 billion tons of carbon into the atmosphere each year in the form of carbon dioxide gas, CO_2. CO_2 weighs 44/12 times the weight of carbon. This is derived from the atomic weights of carbon, 12, and oxygen, 16. The molecular weight (MW) of CO_2 is 12 + (2 x 16) = 44 and the MW of carbon is 12. So CO_2 is 44/12 = 3.67 times heavier than carbon per molecule. Therefore burning one billion tons of carbon produces 3.67 billion tons of CO_2. A) So burning 7 billion tons of carbon will produce 26.7 billion tons of CO_2.

The weight of the Earth's atmosphere can be calculated as follows. Atmospheric pressure at sea level is on average 14.5 pounds per square inch = 10 tons per square meter. This pressure is due to the weight of atmosphere above an area at sea level of one square meter. The radius of the Earth "r" is 5,925 km and so the surface area of the Earth (land and ocean) is 4 x "pi" x "r" squared = 4 x 3.142 x 5925 x 5925 = 441 million square kilometers = 441,000 billion square meters. Therefore the weight of the Earth's atmosphere is 441,000 billion x 10 = 4.41 million billion tons. Now 26.7 billion (the weight in tons of CO_2 emitted into the atmosphere each year, see (A) above), divided by 4.41 million billion gives the fraction 6/one million, which means that the CO_2 emitted to the atmosphere each year from burning fossil fuels is equal to 6 parts per million (ppm) of the atmosphere by weight (6 millionths). It can be seen, therefore, that burning 7 billion tons of carbon from fossil fuels is now dumping 6 ppm per year of CO_2 into the atmosphere. B) Pro-rata, burning one billion tons of carbon from fossil fuels dumps 6/7 = 0.85 ppm of CO_2 into the atmosphere.

The Amazon rainforest is probably absorbing 2 billion tons of carbon per year. Removing this amount of carbon reduces the CO_2 content of the atmosphere by 2 x 0.85 = 1.7 ppm. per year. So the Amazon rain forest is absorbing 1.7 ppm of the 6 ppm of the total CO_2 being emitted by fossil fuel burning.

The current understanding is that at the present level of concentration of CO_2 in the atmosphere CO_2 is being absorbed by natural processes, of which the Amazon rainforest is a major component, at the rate of 3 ppm, i.e. one half of 6 ppm rate at which CO_2 is being dumped into the atmosphere from fossil fuel burning. If CO_2 emissions are rising this will mean that year on year the CO_2 content of the atmosphere will rise by at least one half the previous year's rate of emission.

Therefore at present, CO_2 is increasing by 3 ppm each year (i.e. 6 - 3 = 3 ppm). If the level of fossil fuel burning rises by say only 25% (a much bigger rise is predicted) and if natural processes do not increase their rate of absorption then the rate of increase will become 3 + 25% of 6 = 4.5 ppm per year and if by 2050 we lose the absorption by the Amazon rainforest, the rate of increase becomes 4.5 + 1.7 = 6.2 ppm per year, twice the current level. At this rate, CO_2 levels would increase by 50 x 6 = 300 ppm during the 50 years from 2050 to the end of the century. The increase in CO_2 at today's rate over the 50 years from now to 2050 gives a further increase of 50 x 3 = 150 ppm. So the CO_2 content of the atmosphere by 2050 and 2100 could be:

Today's level in year 2,000	= 350 ppm
Increase at today's rate up to 2050 = 50 years x 3 ppm	= 150 ppm
Increase from 2050 to 2100 assuming 25% growth in fossil fuel use and the Amazon rainforest ceasing to be a CO_2 sink = 50 years x 6 ppm	= <u>300 ppm</u>
Therefore total CO_2 in the atmosphere at 2100	**= <u>800 ppm</u>**

This total does not include CO_2 from Amazon rainforest fires, however, no doubt other forests will expand elsewhere in the world as their conditions become more favorable so release of carbon by forest fires in the Amazon rainforest will be offset by new trees elsewhere but there will be a time lag. Also, non-tropical forests only absorb CO_2 during the spring and summer growing season, whereas tropical forests grow all the year round and tropical forests grow at a faster rate and so absorb more CO_2 than temperate forests.

If 10 years' growth of the Amazon rainforest were released in one year's fires, this would add an additional 10 x 1.7 = 17 ppm CO_2 into the atmosphere in that year.
If the Amazon rainforest becomes savannah, then 90% of the carbon currently locked up in bio-mass would be released. Can we estimate how much carbon this represents? Assume trees at 20 meter spacing, therefore 5 x 5 = 25 trees per hectare. (100m x 100m). Assume 10 tons of carbon per tree, therefore 25 x 10 = 250 tons of carbon per hectare. 1 square km = 100 hectares. Therefore weight of carbon = 25,000 tons/ sq. km. The total area of the Amazon rainforest = 4,000,000 sq. kms. approx.

Therefore, weight of carbon in trees = 25,000 x 4,000,000 = 100 billion tons. If 90% of this carbon returns to the atmosphere as CO_2 this would increase atmospheric CO_2 by 0.9 x 100 x 0.85 (see (B) above) = 76 ppm. The increases in atmospheric CO_2 levels described above are significant increases when compared to historic levels (280 ppm in 1850 and 170 ppm in the recent geological past) and also the rate of change is accelerating. We are entering unknown territory. However, we can project what might happen on the basis of what we do know and the possibilities are awesome.

Source: Hydrogen Now Journal
http://www.hydrogen.co.uk/h2_now/journal/articles/1_global_warming.htm

What is a Carbon Sink?

You won't find it in your kitchen or bathroom: Carbon sinks are natural systems that suck up and store carbon dioxide from the atmosphere.

The main natural carbon sinks are plants, the ocean and soil. Plants grab carbon dioxide from the atmosphere to use in photosynthesis; some of this carbon is transferred to soil as plants die and decompose. The oceans are a major carbon storage system for carbon dioxide. Marine animals also take up the gas for photosynthesis, while some carbon dioxide simply dissolves in the seawater.

"Combined, the Earth's land and ocean sinks absorb about half of all carbon dioxide emissions from human activities," said Paul Fraser of the Commonwealth Scientific and Industrial Research Organization.

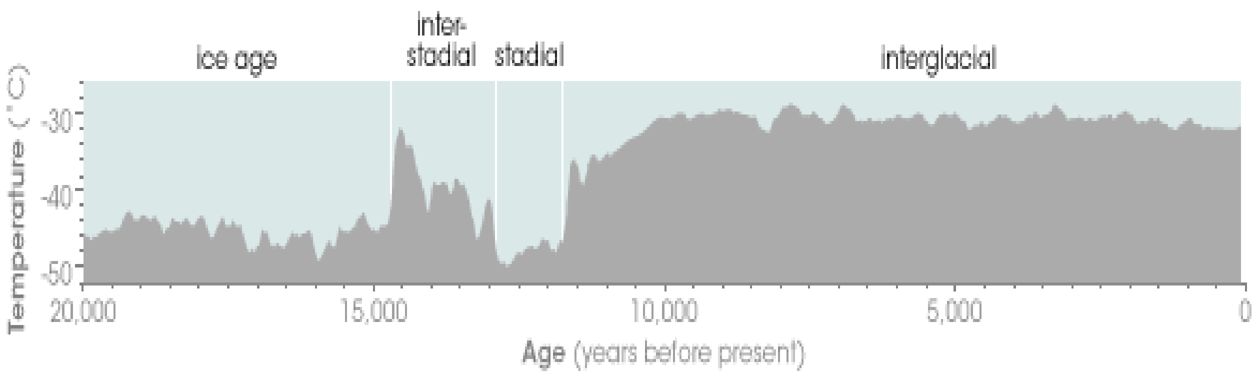
But these sinks, critical in the effort to soak up some of our greenhouse gas emissions, may be stopping up, thanks to deforestation, and human-induced weather changes that are causing the oceanic carbon dioxide "sponge" to weaken, a new study led by Fraser and detailed in the May 18 issue of the journal Science found.

Scientists are looking for ways to help nature along by devising ways to artificially sequester, or store, carbon dioxide underground.

Source: Andrea Thompson
http://www.livescience.com/mysteries/070524_carbon_sink.html

Explaining Rapid Climate Change: Tales from the Ice

When scientists started to analyze the paleoclimate evidence in the Greenland and Antarctic ice cores, they found that the record also supported Milankovitch's theory of when ice ages should occur. But they also found something that required additional explanation: some climate change appeared to have occurred very rapidly. Because Milankovitch's theory tied climate change to the slow and regular variations in Earth's orbit, the scientific community expected that climate change would also be slow and gradual. But the ice cores showed that while it took nearly 10,000 years for the Earth to totally emerge from the last ice age and warm to today's balmy climate, one-third to one-half of the warming—about 15 degrees Fahrenheit—occurred in about 10 years, at least in Greenland. A closer look at marine sediments confirmed this finding. Although the overall timing of the ice ages was clearly tied to variations in the Earth's orbit, other factors must have contributed to climate change as well. Something else made temperatures change very quickly, but what?



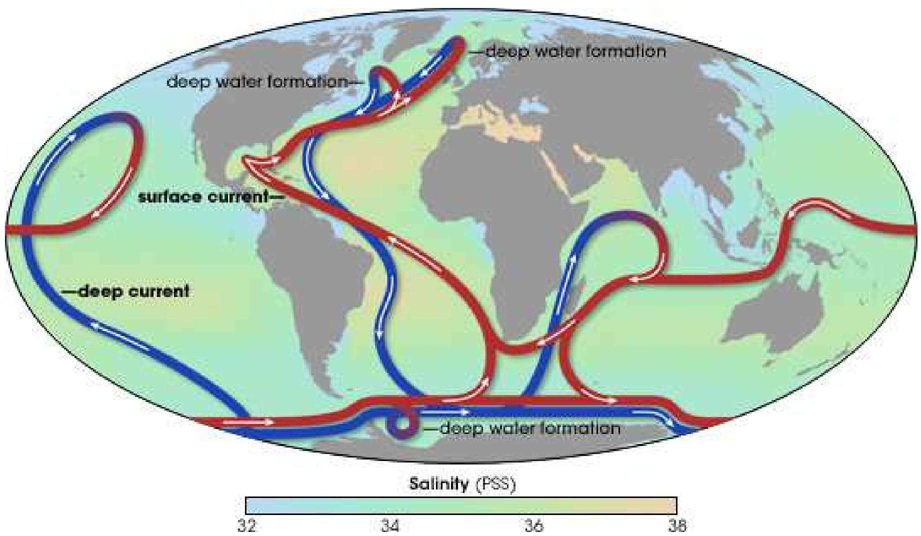
Rapid changes between ice ages and warm periods (called interglacials) are recorded in the Greenland ice sheet. Occurring over one or two decades, the warming of the Earth at the end of the last ice age happened much faster than the rate of change of the Earth's orbit. The last cool period (stadial), immediately before the current interglacial, began and ended suddenly, and was likely caused by changes in the deep ocean circulation. (Graph by Robert Simmon, based on data provided by Alley 2004.)

Greenhouse Gases

Scientists are now exploring a few possibilities. First, greenhouse gases probably influenced past climates. Ice cores record past greenhouse gas levels. In the past, when the climate warmed, the change was accompanied by an increase in greenhouse gases, particularly carbon dioxide. When scientists tried to build climate models, they could not get the models to simulate past climate change unless they also added changes in carbon dioxide levels. Though scientists aren't sure why carbon dioxide levels changed, almost all believe that the shift contributed to altering the climate. Because ice cores also revealed that carbon dioxide levels are much higher today than at any time recorded in the past 750,000 years, pinning down the cause-and-effect relationship between carbon dioxide and climate change continues to be a focal point of modern climate research.

Global Conveyor Belt

Another possible trigger for rapid climate change is ocean circulation. Today, warm water from the equator is carried towards the poles on ocean surface currents. Because of the arrangement of the continents, warm water is carried far into the North Atlantic, moderating the climate in Northern Europe. As the warm surface water reaches the cold air in the north, it cools. The salty Atlantic water becomes very dense as it gets cold. The cold, salty water sinks to the bottom of the ocean before it can freeze, where it is pulled southward toward the equator. More warm water from the equator flows north to replace the sinking water, setting up a global oceanic "conveyor belt."



The large-scale movement of water through the oceans, called the thermohaline circulation, plays a large role in the duration of ice ages. Dense, very salty (saline) water sinks in the North Atlantic, pulling the "conveyor belt" of currents behind it. The conveyor belt carries heat from the equator towards the poles, and raises Arctic temperatures, discouraging the growth of ice sheets. Influxes of fresh water from the lands that surround the North Atlantic can slow or shut down the circulation, cooling the Northern Hemisphere. This map shows the general location and direction of the warm surface (red) and cold deep water (blue) currents of the thermohaline circulation. Salinity is represented by color in units of the Practical Salinity Scale. Low values (blue) are less saline, while high values (orange) are more saline. (Map by Robert Simmon, adapted from the IPCC 2001 and Rahmstorf 2002.)

This pattern helps keep Northern Europe far warmer than other locations at the same latitude. The key to keeping the belt moving is the saltiness of the water, which increases the water's density and causes it to sink. Many scientists believe that if too much fresh water enters the ocean, for example, from melting Arctic glaciers and sea ice, the water will be diluted. Fresh water freezes at a higher temperature than salty water, so the cooling surface water would freeze before it could become dense enough to sink toward the bottom. If the water in the north does not sink, the water at the equator will not move north to replace it. The currents would eventually stop moving warm water northward, leaving Northern Europe cold and dry within a single decade.

This theory of rapid climate change is called the conveyor belt theory, and though many scientists do not yet agree with it, the paleoclimate record found in ocean sediment cores is beginning to support it. Recent paleoclimate studies have shown that when heat circulation in the North Atlantic Ocean slowed in the past, the climate changed in Northern Europe. Although the last ice age peaked about 20,000 years ago, the warming trend was interrupted at various points by cold spells. In a paper published in *Nature* on April 22, 2004, McManus and colleagues Roger Francois, Jeanne Gherardi, Lloyd Keigwin and Susan Brown-Leger at Woods Hole Oceanographic Institute and the Laboratoire des Sciences du Climat et de l'environnement in France showed that cold periods in Europe 17,500 and 12,700 years ago happened just after melting ice diluted the salty North Atlantic water, and the ocean conveyor belt slowed. The evidence, which they took from radioactive elements in ocean cores, is beginning to support the theory, but McManus cautions that there are still pieces to fill in before we fully understand what role the conveyor belt played in past climate change and what role it might play in the future.

Source: NASA, http://earthobservatory.nasa.gov/Features/Paleoclimatology_Evidence/paleoclimatology_evidence_2.php

Links:

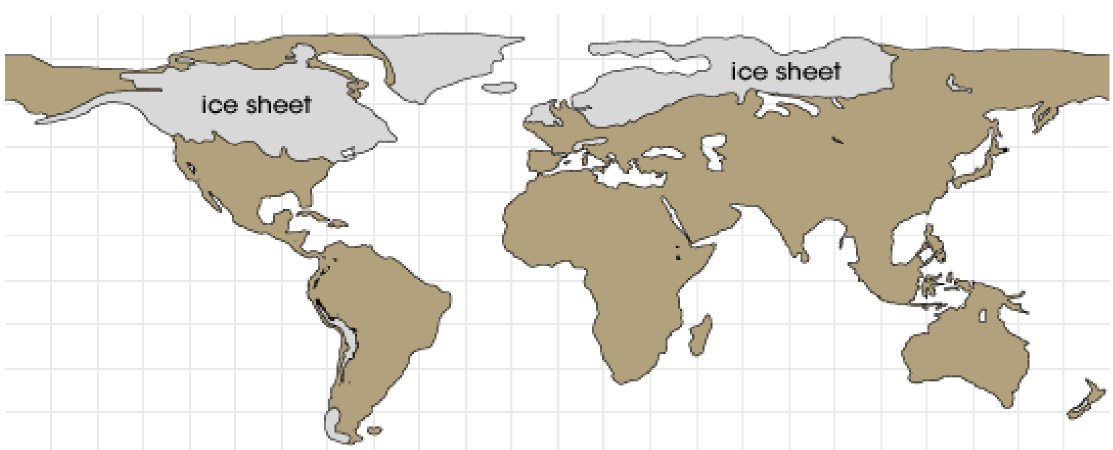
- Intergovernmental Panel on Climate Change
- Milankovitch Cycles
- Milutin Milankovitch
- NOAA Paleoclimatology Program

Paleoclimatology: Written in Earth

The first pieces of evidence for climate change came from the land itself, from the misplaced boulders scattered across much of the Northern Hemisphere, though there were other signs as well. A homogeneous, fine yellow soil covered more than one million square miles of Europe, Asia, and North America. The soil was as thick as 3 meters (10 feet) in some places, and nearly nonexistent in others. Scientists eventually recognized that the soil, called loess (rhymes with "bus"), was made of rock that had been ground into powder under the weight and movement of the glaciers. As the ice melted, water swept the dust out from under the glaciers into streams along the edge of the ice. When water levels dropped, the dust blew across the land, leaving an uneven layer of fine, homogeneous soil.

Loess deposits, composed of fine wind-blown dust produced by the grinding action of glaciers, indicate the former presence of ice sheets in locations around the Northern Hemisphere. This exposure of loess is near Palouse, Washington.

By mapping the loess and the trail of rock debris left by the glaciers, scientists determined that the ice sheets had once stretched down over the familiar bowls of the Great Lakes in North America and across the British Isles and Scandinavia. Thick glaciers, far larger than those that currently cap the mountain peaks, covered the Alps. In time, geologists discovered other layers of similar soil from earlier times—a sign that the climate had not changed just once, but at least three or four times.



Ice sheets covered much of North America, northern Europe, and Siberia during the last ice age.

The story of glaciation and climate change may have been etched into rocks and brushed from the soil like a giant sand painting, but then Nature left the book out in the open. Exposed to erosion and weathering for thousands, even millions of years, some parts of the original story have been revised or become difficult to read. Buried in the Earth, however, is another version of the Earth's climate story, and scientists have begun to leaf through its pages.

Speleothems: Cave rocks

A deep cavern dips into the New Mexico desert, shielding spiky icicle-like rocks that hang from the ceiling and the rounded columns that grow from the floor in a myriad of shapes. One of the world's largest underground chambers, the Carlsbad Cavern is resplendent in the intricate finery of the rock formations that form there. Beyond their breath-taking beauty, the formations in Carlsbad and the more than 100 other caves in the area provide a record of rainfall in the southwestern United States.

Spectacular rock formations in Carlsbad Cavern hold information on past rainfall and temperatures.

Minerals dissolved in groundwater can crystallize on exposed surfaces of underground passages. The deposited minerals form stalactites, stalagmites, and other formations, collectively named *speleothems*. Soda straw stalactites are delicate tubes of calcium carbonate (limestone).

Tucked away inside the Earth, the rocks are protected from the weathering and large-scale erosion that taints other land-based climate records. As water runs through the ground, it picks up minerals, the most common of which is calcium carbonate. When the mineral-rich water drips into caves, it leaves behind solid mineral deposits—the same solid material that forms white spots on water faucets or glass dishes. The mineral deposits accumulate in the well-known icicle-shaped rock on the ceiling, a stalactite, and in a mound on the floor where the drip lands, a stalagmite. Less well known, water deposits can also dry in a flat slab called a flowstone.

Geologists refer to the mineral formations in caves as speleothems. While the water flows, the speleothems grow in thin, shiny layers. The amount of growth is an indicator of how much ground water dripped into the cave. Little growth might indicate a drought, just as rapid growth could point to heavy precipitation. When the speleothems stop growing, the outside becomes dirty and eroded in places, giving it a dull appearance. A growing speleothem looks smooth and wet.

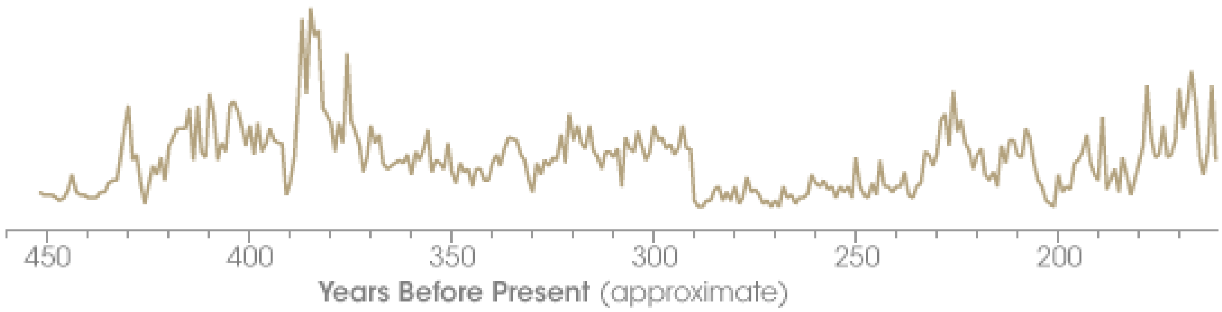
Flowing water builds stalactites, stalagmites, and flowstones one drip at a time (left). When a cave feature dries out (right), growth stops.

Scientists can date the layers in the speleothem by measuring how much uranium, a radioactive element, has decayed. Uranium from the surrounding bedrock seeps into the water and forms a carbonate that becomes part of each layer of the speleothem as it forms. Uranium decays into thorium, which sticks to the clay in the bedrock instead of seeping into ground water and from there into the speleothem. As a result, the newest layers of a growing speleothem typically contain no thorium.

Over time uranium predictably turns into thorium, so scientists can tell how old a layer is by measuring the ratio of uranium to thorium. Once the layers have been dated, scientists can create a rough record of how ground water levels changed over the lifetime of the formation. Because speleothem growth is influenced by geography, ground water chemistry, and other factors, the record from one cave cannot serve as a record of climate change. Scientists must look for similar patterns of growth in speleothems in caves over a broad area to infer that the climate changed.

The cross section of a stalagmite reveals a sequence of layers, laid down over time. Researchers determine the age of the rings using Uranium-Thorium radioisotopic dating, and examine ring thickness and oxygen isotopes to determine past climate.

Scientists are trying to glean more climate information from speleothems. The rocks could provide a climate record through the oxygen isotope ratios. Oxygen in water comes in two important varieties for paleoclimate research: heavy and light. The ratio of these different types of oxygen in water vary based on air temperature, the total amount of ice in the world, and the amount of local precipitation—all important pieces of the climate puzzle. To an extent, the ratio is preserved in the cave rocks, and scientists can use this clue to learn about the climate at the time the rock formed.



Paleoclimatologists analyze the growth rate of stalactites and stalagmites to reveal patterns of past rainfall. This graph shows the thickness of near-annual growth rings for the past 450 years from a stalagmite in Carlsbad Cavern. Thick rings indicate a relatively wet climate, while thin rings indicate a dry climate.

Recently, scientists have started to use the oxygen isotope ratio to track changes in the amount of rainfall (heavy rain results in more light oxygen) or changes in where the rain came from—the ocean or inland sources. "In southeast Brazil, for example, winter rain comes from the nearby Atlantic Ocean, but summer rain comes from the Amazon Basin," says Stephen J. Burns, a geochemist at the University of Massachusetts. "The two have quite different oxygen isotope ratios." By examining the ratios in the rocks, Burns and others can track seasonal changes and rainfall patterns. Since caves exist all over the Earth, speleothems have the potential to become a pivotal land-based climate record.

Other land features help fill in the picture of climate in the past. Water marks trace the shorelines of ancient lakes where none exist now. Beaches record changes in sea level as ice sheets formed, and then melted. Dust deposits reveal where winds blew across ancient deserts. Fossils of animals and plants—even microscopic fossilized pollen grains—give clues about the climate where and when those organisms lived.

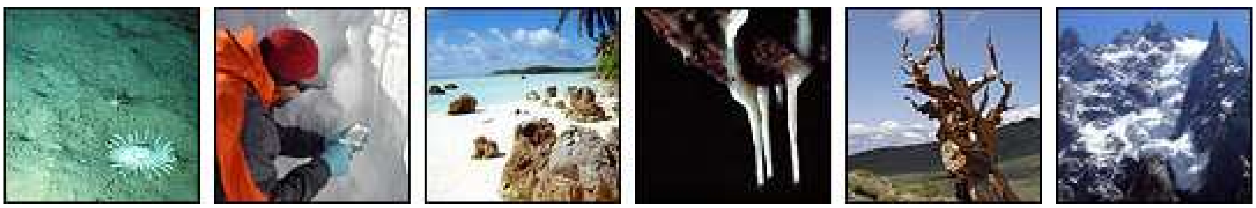
While these artifacts in the Earth are valuable to scientists reconstructing large-scale climate patterns on land, most have been disturbed by subsequent weathering. For a global picture of past climate, scientists also need a consistent record that covers a broad section of the Earth. For that, they turn to the oceans.

Features on the Earth's modern surface hint at the surface in the past. After the last ice age, Glacial Lake Missoula left behind fossil shore lines (left)—flat, parallel benches—on many hillsides in western Montana. Layers of sediment, exposed by erosion (right), were also left behind by the lake. Researchers use these features to reconstruct past cli-

Source: NASA, http://earthobservatory.nasa.gov/Features/Paleoclimatology_Speleothems/

Paleoclimatology: Explaining the Evidence

From the oceans' depths to the polar ice caps, clues to the Earth's past climates are engraved on our planet. Sea sediments reveal how much ice existed in the world and hint at past temperatures and weather patterns. Ice cores also provide a glimpse of past temperatures and preserve tiny bubbles of ancient atmosphere. Coral, tree rings, and cave rocks record cycles of drought and rainfall. Each piece of this complex puzzle must be put together to give us a picture of Earth's climate history. Scientists' efforts to explain the paleoclimate evidence—not just the when and where of climate change, but the how and why— have produced some of the most significant theories of how the Earth's climate system works.

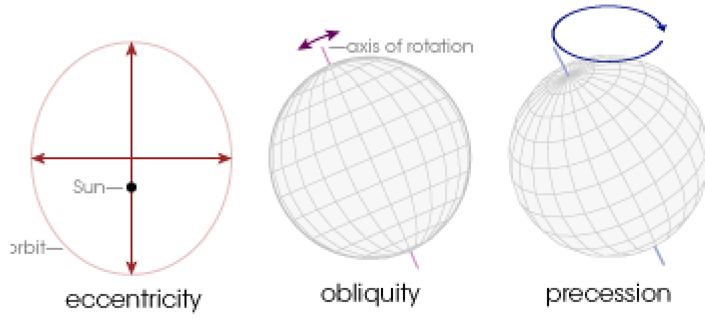


Sea-floor sediments, ice sheets, corals, cave formations, ancient trees, and alpine glaciers all hold clues to past climates. Scientists have assembled a coherent picture of the Earth's climate history by combining data from all these and other sources. [Photographs copyright (left to right) Woods Hole Oceanographic Institute, Reto Stöckli, National Oceanic and Atmospheric Administration, National Park Service, Jessica Bray, and Robert Simmon.]

The Earth's Shifting Orbit

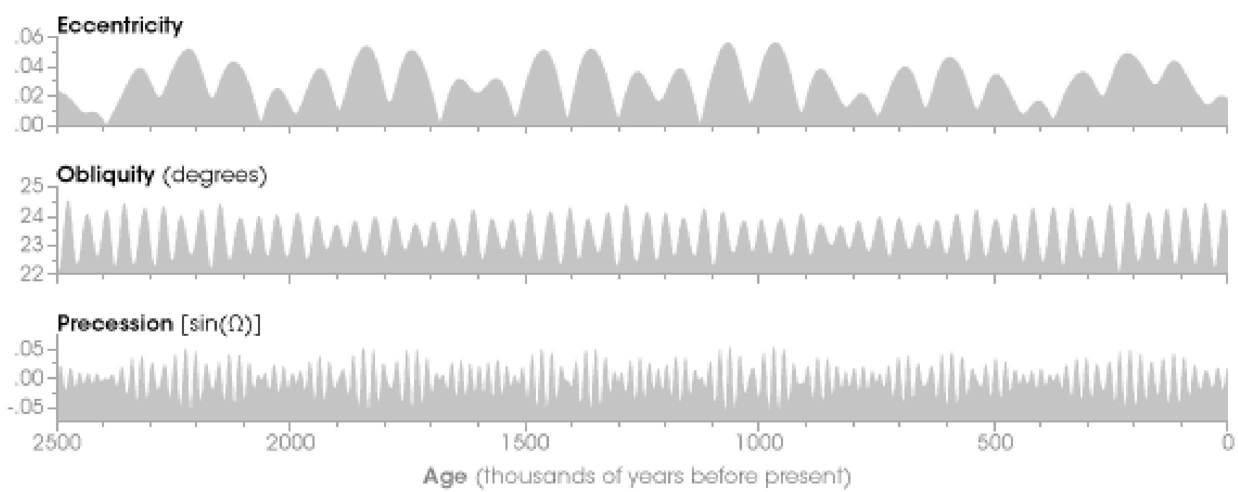
From the scratched rocks strewn haphazardly across the landscape and the thin layer of soil left behind by retreating glaciers, scientists learned that the Earth had gone through at least three or four ice ages. Noticing that the ice came and went cyclically, they began to suspect that the ice ages were connected to variations in the Earth's orbit.

The Earth circles the Sun in a flat plane. It is as if the spinning Earth is also rolling around the edge of a giant, flat plate, with the Sun in the center. The shape of the Earth's orbit—the plate—changes from a nearly perfect circle to an oval shape on a 100,000-year cycle (*eccentricity*). Also, if you drew a line from the plate up through the Earth's North and South Poles—Earth's axis—the line would not rise straight up from the plate. Instead the axis is tilted, and the angle of the tilt varies between 22 and 24 degrees every 41,000 years (*obliquity*). Finally, the Earth wobbles on its axis as it spins. Like the handle of a toy top that wobbles toward you and away from you as the toy winds down, the "handle" of the Earth, the axis, wobbles toward and away from the Sun over the span of 19,000 to 23,000 years (*precession*). These small variations in Earth-Sun geometry change how much sunlight each hemisphere receives during the Earth's year-long trek around the Sun, where in the orbit (the time of year) the seasons occur, and how extreme the seasonal changes are.



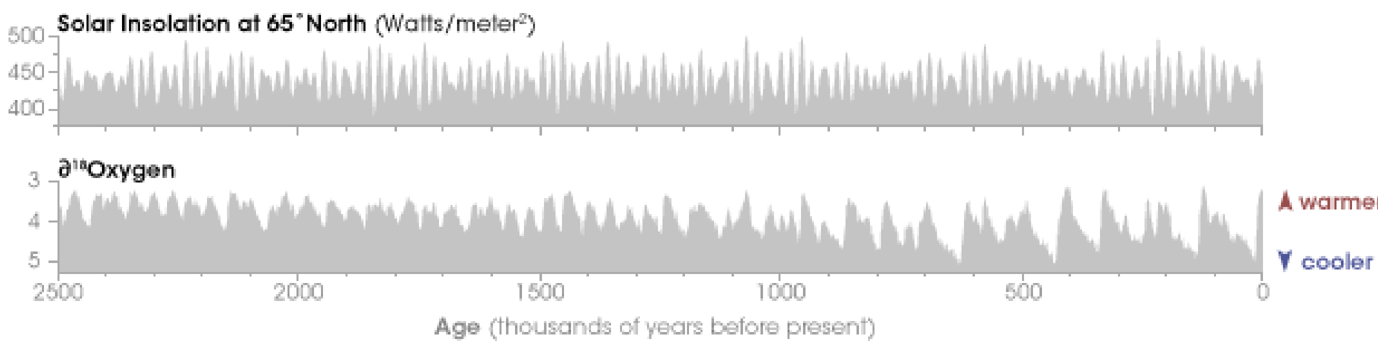
Three variables of the Earth's orbit—eccentricity, obliquity, and precession—affect global climate. Changes in eccentricity (the amount the orbit diverges from a perfect circle) vary the distance of Earth from the Sun. Changes in obliquity (tilt of Earth's axis) vary the strength of the seasons. Precession (wobble in Earth's axis) varies the timing of the seasons.

In the early 1900s, a Serbian mathematician named Milutin Milankovitch meticulously calculated the amount of sunlight each latitude received in every phase of Earth's orbital variations. His work culminated in the 1930 publication of *Mathematical Climatology and the Astronomical Theory of Climate Change.* He theorized that the ice ages occurred when orbital variations caused the Northern Hemisphere around the latitude of the Hudson Bay and northern Europe to receive less sunshine in the summer. Short, cool summers failed to melt all of the winter's snow. The snow would slowly accumulate from year to year, and its shiny, white surface would reflect more radiation back into space. Temperatures would drop even further, and eventually, an ice age would be in full swing. Based on the orbital variations, Milankovitch predicted that the ice ages would peak every 100,000 and 41,000 years, with additional "blips" every 19,000 to 23,000 years.



The Earth's orbit varies over tens and hundreds of thousands of years. Combined changes in eccentricity, obliquity, and precession alter the strength and location of sunlight falling on the Earth's surface. (Graphs by Robert Simmon based on data from Berger 1992.)

The paleoclimate record shows peaks at exactly those intervals. Ocean cores showed that the Earth passed through regular ice ages—not just the 3 or 4 recorded on land by misplaced boulders and glacial loess deposits—but 10 in the last million years, and around 100 in the last 2.5 million years.



(Upper graph) The rise and fall of the intensity of sunlight *(insolation)* in the far North during the summer—determined by the Earth's orbit—drives ice ages. Weak summer sunlight year after year allows snow to accumulate and glaciers to advance. The reflective ice sheets further cool the Earth's surface, resulting in global ice ages. When the Northern Hemisphere receives more sunlight, the snow melts, ice sheets retreat, and Earth warms.

(Lower graph) Oxygen isotopes trapped in ocean sediments record cycles of ice ages millions of years into Earth's past. This climate record matches the frequency of orbital changes, although tangled feedbacks make the relationship complex. Dips represent ice ages, and spikes represent interglacials. (Graph by Robert Simmon, based on data from Berger 1992 and Lisiecki 2005.)

Evidence supporting Milankovitch's theory of the precise timing of the ice ages first came from a series of fossil coral reefs that formed on a shallow ocean bench in the South Pacific during warm interglacial periods. As the ice ages came, more and more water froze into polar ice caps and the ocean levels dropped, leaving the reef exposed. When the ice melted, the ocean rose and warmed, and another reef formed. At the same time, the peninsula on which the reefs formed was steadily being pushed up by the motion of the Earth's shifting tectonic plates. Today, the reefs form a visible series of steps along the shore of Papua New Guinea. The reefs, the age of which was well-defined because of the decaying uranium in the coral, measured out the millennia between ice ages. They also defined the maximum length of each ice age. The intervals fell exactly where Milankovitch said they would.

Source: NASA, http://earthobservatory.nasa.gov/Features/Paleoclimatology_Evidence/

Climate Change — Research Suggests It Is Not a Swindle

New research has dealt a blow to the skeptics who argue that climate change is all due to cosmic rays rather than to man-made greenhouse gases. The new evidence shows no reliable connection between the cosmic ray intensity and cloud cover. Lauded and criticized for offering a possible way out of the dangers of man made climate change, UK TV Channel 4's program The Great Global Warming Swindle, broadcast in 2007, suggested that global warming is due to a decrease in cosmic rays over the last hundred years.

This would cause a decrease in the production of low clouds allowing more heat from the sun to warm the Earth and cause global warming. Research published today, Thursday 3 April, 2008, in the Institute of Physics' Environmental Research Letters shows how a team from Lancaster and Durham Universities sought a means to prove the correlation between the ionizing cosmic rays and the production of low cloud cover.

Previous research had shown a possible hint of such a correlation, using the results of the International Satellite Cloud Climatology Project, and this had been used to propose that global warming was all down to cosmic rays.

The new research shows that change in cloud cover over the Earth does not correlate to changes in cosmic ray intensity. Neither does it show increases and decreases during the sporadic bursts and decreases in the cosmic ray intensity which occur regularly. One such very large burst caused the magnetic storm which blacked out the power in Quebec in 1989.

Professors Sloan from Lancaster University and Wolfendale from Durham University write, "No evidence could be found of changes in the low cloud cover from known changes in the cosmic ray ionization rate."

Source: NASA, http://earthobservatory.nasa.gov/Newsroom/view.php?id=34262

The Carboniferous

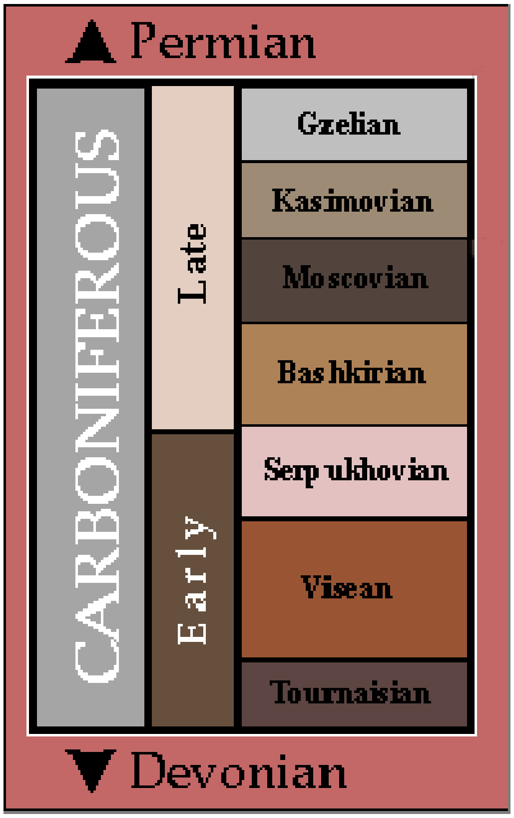
354 to 290 Million Years Ago

The Carboniferous Period occurred from about 354 to 290 million years ago during the late Paleozoic Era. The term "Carboniferous" comes from England, in reference to the rich deposits of coal that occur there. These deposits of coal occur throughout northern Europe, Asia, and mid-western and eastern North America. The term Carboniferous is used throughout the world to describe this period, although this period has been separated into the **Mississippian** (Lower Carboniferous) and the **Pennsylvanian** (Upper Carboniferous) in the United States. This system was adopted to distinguish the coal-bearing layers of the Pennsylvanian from the mostly limestone Mississippian, and is a result of differing stratigraphy on the different continents.

Carboniferous Forest: The Carboniferous Period is famous for its vast coal swamps, such as the one depicted here. Such swamps produced the coal from which the term Carboniferous, or carbon-bearing comes.

In addition to having the ideal conditions for the beginnings of coal, several major biological, geological, and climatic events occurred during this time. One of the greatest evolutionary innovations of the Carboniferous was the amniote egg, which allowed for the further exploitation of the land by certain tetrapods. The amniote egg allowed the ancestors of birds, mammals, and reptiles to reproduce on land by preventing the desiccation of the embryo inside. There was also a trend towards mild temperatures during the Carboniferous, as evidenced by the decrease in lycopods and large insects and an increase in the number of tree ferns.

Geologically, the Late Carboniferous collision of **Laurussia** (present-day Europe and North America) into **Godwanaland** (present-day Africa and South America) produced the Appalachian mountain belt of eastern North America and the Hercynian Mountains in the United Kingdom. A further collision of Siberia and eastern Europe created the Ural Mountains.



Subdivisions of the Carboniferous:

The chart at left shows the major subdivisions of the Carboniferous Period. The Lower Carboniferous of Europe corresponds roughly to the Mississippian of North America, and the Middle and Upper Carboniferous are roughly equivalent to the Pennsylvanian. This chart is mapped, to allow you to travel back to the Devonian or forward to the Permian. The Carboniferous Period is part of the Paleozoic Era.

Source: Page content rewritten and completed 11 May 1998 by Angela Hoe, Azalea Jusay, Ray Mayberry, and Connie Yu as part of a Biology 1B project for Section 115, under Brian R. Speer (GSI), University of California. Carboniferous pages updated to reflect Geological Society of America (GSA) 1999 Geologic Timescale, compiled by A.R. Palmer and J. Geissman, S. Rieboldt, November 2002.

Climate and the Carboniferous Period

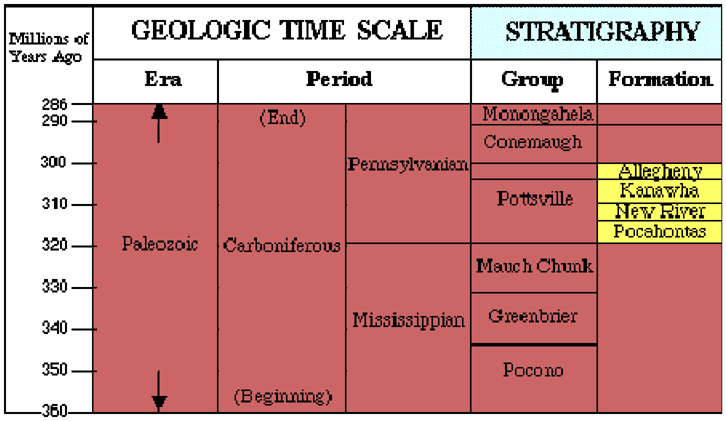
West Virginia today is mostly an erosional plateau carved up into steep ridges and narrow valleys, but 300 million years ago, during the Carboniferous Period, it was part of a vast equatorial coastal swamp extending many hundreds of miles and barely rising above sea level. This steamy, tropical quagmire served as the nursery for Earth's first primitive forests, comprised of giant lycopods, ferns, and seed ferns.

North America was located along Earth's equator then, courtesy of the forces of continental drift. The hot and humid climate of the Middle Carboniferous Period was accompanied by an explosion of terrestrial plant life. However, by the late Carboniferous Period, Earth's climate had become increasingly cooler and drier. By the beginning of the Permian Period, average global temperatures declined by about 10° C.

Interestingly, the last half of the Carboniferous Period witnessed periods of significant ice cap formation over polar landmasses — particularly in the southern hemisphere. Alternating cool and warm periods during the ensuing Carboniferous Ice Age coincided with cycles of glacier expansion and retreat. Coastlines fluctuated, caused by a combination of both local basin subsidence and worldwide sea level changes. In West Virginia a complex system of meandering river deltas supported vast coal swamps that left repeating stratigraphic levels of peat bogs that later became coal, separated by layers of fluvial rocks like sandstone and shale when the deltas were building, and marine rocks like black shales and limestones when rising seas drowned coastlands. Accumulations of several thousand feet of these sediments over millions of years produced sufficient heat and pressure to transform the soft sediments into rock and the peat layers into the 100 or so coal seams which today comprise the Great Bituminous Coalfields of the Eastern U.S. and Western Europe.

Earth's climate and atmosphere have varied greatly over geologic time. Our planet has mostly been much hotter and more humid than we know it to be today, and with far more carbon dioxide (the greenhouse gas) in the atmosphere than exists today. The notable exception is 300,000,000 years ago during the late Carboniferous Period, which resembles our own climate and atmosphere like no other.

With this in mind, the road to understanding global warming and our present climate begins with an historical journey through a chapter in Earth's history, some 30 million years before dinosaurs appeared, known as the Carboniferous Period — a time when terrestrial Earth was ruled by giant plants and insects, and glaciers waxed and waned



The Carbon in Carboniferous

An intriguing story of climate change is recorded in the rocks which comprise the geological formations laid down during the Carboniferous Period. Coal deposits play an important role in this record. Coal is mostly carbon accumulations from fossil plant material deposited in swamps so devoid of oxygen that bacteria and other critters couldn't survive to feed on their remains. The explosion of luxuriant plant growth and coal bed formation that occurred 286-360 million years ago is the reason for the name, Carboniferous Period.

North American geologists have found it convenient to divide the Carboniferous Period into two parts: The first half is called the Mississippian Period and is characterized by deposition of mostly thick marine limestone in shallow, tropical seas. The last half of the Carboniferous is called the Pennsylvanian Period, and contains mostly sediments and coal seams created by meandering river deltas periodically interrupted by marine inundations. Many places around the world contain important coal beds deposited during this time period.

In West Virginia the various coal seams have each been given their own unique names: like Pocahontas, Sewell, Eagle, or Coalburg. There are subtle but noticeable changes in the character and properties of the coal beds throughout the Pennsylvanian Period, most likely due to Earth's cooling climate and quite possibly also due to declining atmospheric carbon dioxide concentrations.

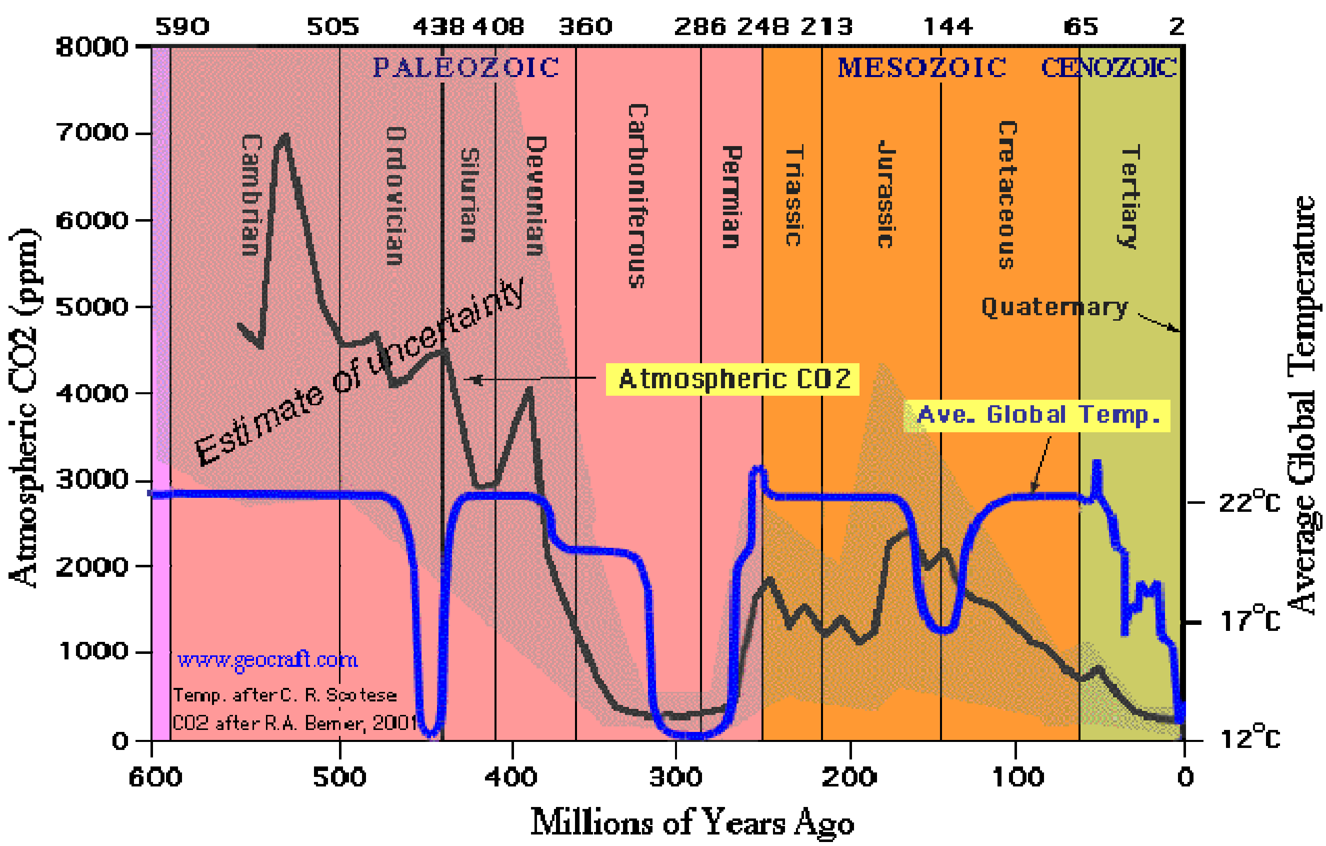
Early Pennsylvanian coal seams like those found in the Pocahontas and New River Formations were characteristically friable, shiny, and vitreous, indicating deposition in a continuously wet, humid environment. In contrast, coals of the Allegheny Formation that followed (Middle Pennsylvanian) are predominantly hard, dull, and splinty, indicating that by then the climate had already become drier, most likely cooler, and generally a more stressful place for terrestrial plant life. The Coalburg and Stockton seams, deposited around 307-305 million years ago, mark the geologic boundary at which a shift from tropical to temperate climate appears to have occurred. The Kanawha Formation, represents deposition in a transitional climate, with coal seams containing alternating layers of vitreous and splinty layers, called banded coals.

Similarities with Our Present World

Average global temperatures in the Early Carboniferous Period were hot, approximately 20° C (68° F). However, cooling during the Middle Carboniferous reduced average global temperatures to about 12° C (54° F). As shown on the chart below, this is comparable to the average global temperature on Earth today. Similarly, atmospheric concentrations of carbon dioxide (CO_2) in the Early Carboniferous Period were approximately 1500 ppm (parts per million), but by the Middle Carboniferous had declined to about 350 ppm -- comparable to average CO_2 concentrations today!

Earth's atmosphere today contains about 380 ppm CO_2 (0.038%). Compared to former geologic times, our present atmosphere, like the Late Carboniferous atmosphere, is CO_2 impoverished. In the last 600 million years of Earth's history only the Carboniferous Period and our present age, the Quaternary Period, have witnessed CO_2 levels less than 400 ppm.

Global Temperature and Atmospheric CO_2 over Geologic Time



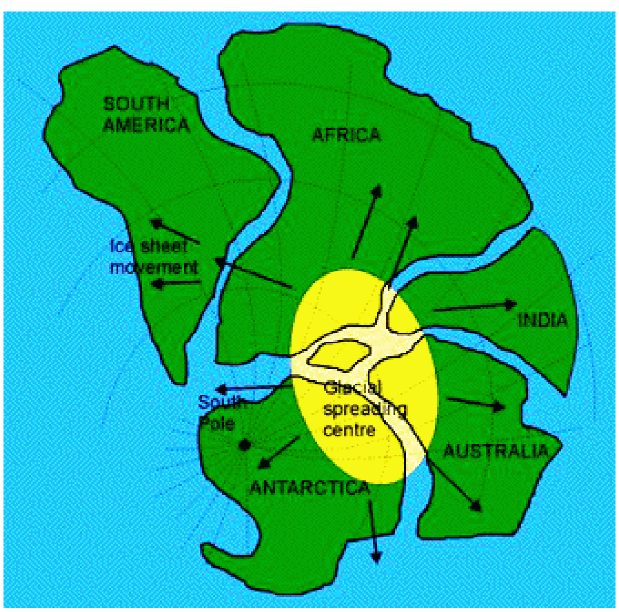
Late Carboniferous to **Early Permian** time (315 mya -- 270 mya) is the only time period in the last 600 million years when **both** atmospheric **CO_2** and **temperatures** were as low as they are today **(Quaternary Period).**

There has historically been much more CO_2 in our atmosphere than exists today. For example, during the Jurassic Period (200 mya), average CO_2 concentrations were about 1800 ppm or about 4.7 times higher than today. The highest concentrations of CO_2 during all of the Paleozoic Era occurred during the Cambrian Period, nearly 7000 ppm — about 18 times higher than today.

The Carboniferous Period and the Ordovician Period were the only geological periods during the Paleozoic Era when global temperatures were as low as they are today. To the consternation of global warming proponents, the Late Ordovician Period was also an Ice Age while at the same time CO_2 concentrations then were nearly 12 times higher than today — 4400 ppm. According to greenhouse theory, Earth should have been exceedingly hot. Instead, global temperatures were no warmer than today. Clearly, other factors besides atmospheric carbon influence earth temperatures and global warming.

The Carboniferous Ice Age

Two special conditions of terrestrial landmass distribution, when they exist concurrently, appear as a sort of common denominator for the occurrence of very long-term simultaneous declines in both global temperature and atmospheric carbon dioxide (CO2): 1) the existence of a continuous continental landmass stretching from pole to pole, restricting free circulation of polar and tropical waters, and 2) the existence of a large (south) polar landmass capable of supporting thick glacial ice accumulations.



These special conditions existed during the Carboniferous Period, as they do today in our present Quaternary Period. Climate change during the Carboniferous Period was dominated by the great Carboniferous Ice Age. As the Earth alternately cooled then warmed, great sheets of glacial ice thousands of feet thick accumulated, then melted, then re-accumulated in synchronous cycles. Vast glaciers up to 8,000 feet thick existed at the south pole then, moving from higher elevations to lower, driven by gravity and their tremendous weight. These colossal slow-motion tidal waves of ice destroyed and pulverized everything in their path, scraping the landscape to bare bedrock — altering mountains, valleys, and river courses. Ancient bedrock in Africa, Australia, India and South America show scratches and gouges from this glaciation.

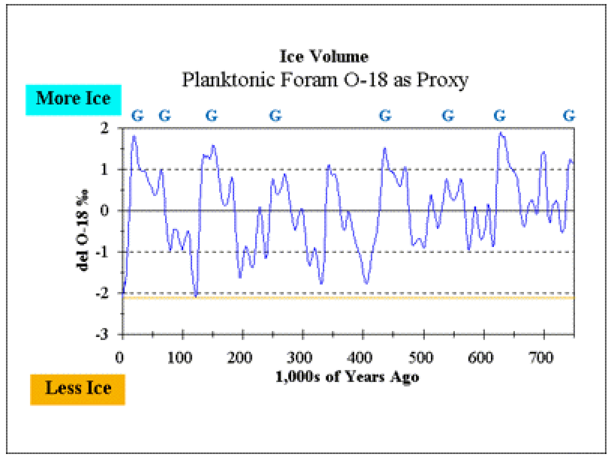
Earth's continents during the Carboniferous Period were arranged differently than they are today. South America, Africa, India, Australia, Antarctica, and a few minor pieces were joined together near the south pole to comprise the supercontinent known as Gondwanaland. Gondwanaland was a formidable polar landmass. While ice caps and glaciers can't grow large over open oceans, they can and do attain great thickness over polar continents — like Gondwanaland.

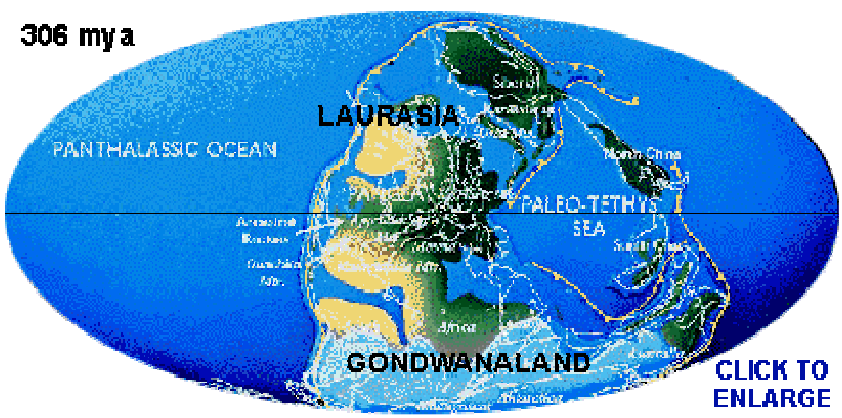
Although cycles of glaciation are believed to occur in response to solar input variations like the Milankovich Cycle and Precession of the Equinoxes, another important factor is the rearrangement of continental landmasses over geologic time by the processes of continental drift.

Throughout the Carboniferous Period, continental drift was rearranging most (but not all) of the Earth's landmasses into a single supercontinent stretching from the south polar region to the north polar region. Although the precise mechanisms involved are still a matter of debate, this appears to cause regional humidity changes and redistribution of ocean currents which in turn promote ice accumulation and glacier formation over the earth's polar continents. These glacial ice caps grow larger during periods of reduced solar input, and, because ice caps are very good solar reflectors this tended to accelerate and perpetuate cyclical relapses to global cooling. Basically, Earth undergoes alternating periods of ice ages and warming whenever a continuous continental landmass extends from one polar region to the other while at the same time there exists a large polar continent capable of supporting thick ice accumulations. These conditions existed 300 million years ago during the Carboniferous Period as they do for the Earth today. However, for most of geologic history the distribution of the continents across the globe did not satisfy this criteria. Continental drift continually rearranges the continents, moving at rates of only a few centimeters per year.

We are actually in an ice age climate today. However, for the last 10,000 years or so we have enjoyed a warm but temporary interglacial vacation. We know from geological records like ocean sediments and ice cores from permanent glaciers that for at least the last 750,000 years interglacial periods happen at 100,000 year intervals, lasting about 15,000 to 20,000 years before returning to an icehouse climate. We are currently about 18,000 years into Earth's present interglacial cycle. These cycles have been occurring for at least the last 2-4 million years, although the Earth has been cooling gradually for the last 30 million years.

Over the past 750,000 years of Earth's history, Ice Ages have occurred at regular intervals, of approximately 100,000 years each.





Floating atop a mantle of hot, ductile rock, the continents and ocean plates drift like gargantuan icebergs, crashing into each other, building mountain ranges and volcanic belts as they go. The phenomena is known as continental drift and the process has been going on for hundreds of millions of years — at rates measured in only a few centimeters per year.

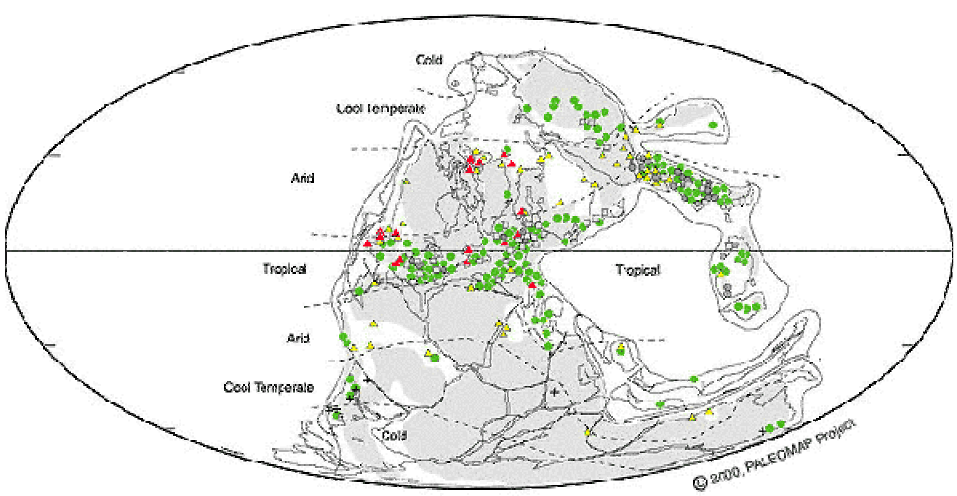
Illustrated above is how geologists believe Earth's landmasses were arranged 306 million years ago, during the Late Carboniferous Period. Many of the continents we know today were recognizable then — some more easily than others. Parts of them were either under water or hadn't been assembled yet, and almost all were part of one of two larger landmasses known as Gondwanaland and Laurasia.

Antarctica, Africa, Arabia, India, Ceylon, Australia, New Zealand and South America together comprised Gondwanaland. It was positioned near the south pole, and during the Late Carboniferous Period was largely buried under large sheets of glacial ice. Europe, Greenland, Siberia, North America, Kazakhstan, and N. China together comprised Laurasia. It was still adding real estate to itself throughout the Carboniferous and into the Permian Period.

Pangea (Greek for all lands) is the supercontinent created when these two giant landmasses drifted into one another, a process that was complete by the middle of the Permian Period. Later, during the Jurassic Period, the Pangean Supercontinent began to break up and the separate continents once again drifted apart — a process which continues today. During Late Carboniferous time the continent of North America lay much further south than it does today. North America and parts of Europe were in the tropics. The equator stretched from central Colorado to Nova Scotia and also from Great Britain to the Ukraine.

A broad Central Pangean mountain range formed an equatorial highland that during late Carboniferous was the locus of coal production in an equatorial rainy belt (1). This produced vast amounts of sediments which were transported to equatorial coastal regions, forming deltas which supported vast coal swamps. Throughout the Late Carboniferous (Pennsylvanian) Period, Pangea drifted northward to drier, cooler climates and by the mid-Permian North America and Northern Europe had become desert-like as continued mountain-building caused much of the interior of the vast Pangean Supercontinent to be in rain shadow.

The Great Bituminous Coalfields of the Eastern U.S., Europe, and Northern China were primarily deposited during the Upper Carboniferous Period, attesting to the fact that even in the cold, icehouse climate of the Carboniferous Period lush vegetation still persisted in the world's tropical and cool temperate regions. The map projection below shows the general worldwide distribution of many of the significant coal deposits of the Late Carboniferous.



Upper Carboniferous (Bashkirian - Moscovian)

<table>
<tr><td>COAL</td><td rowspan="3">During the Upper Carboniferous Period (a.k.a. Pennsylvanian Period: 286-320 mya) nearly all the continents were joined as one giant landmass called Pangea (meaning all lands). While massive glaciers existed at the south pole, tropical swampland forests along the equator produced vast peat beds which after deep burial and subsequent heat and pressure were transformed into the Great Bituminous Coalfields of the eastern U.S and western Europe.</td></tr>
<tr><td>Evapor-ites</td></tr>
<tr><td>Calcretes</td></tr>
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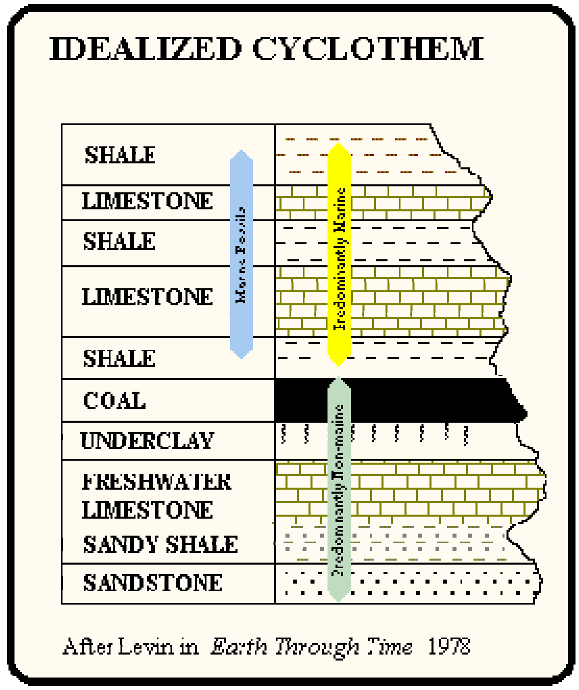
Ice Age Sea Level Oscillations and Coal Deposits
Warm to moderate temperatures and high humidity alone do not produce all the conditions necessary for creating coal deposits. Steadily rising sea level and/or steady regional swamp subsidence are also necessary. As a prerequisite to the formation of thick coal seams it is necessary that the rate of vegetable matter accumulation remain in general equilibrium with the rate of rising water levels for relatively long periods. Rise too fast, and the swamp gets drowned, rise too slowly and dead plant material is not completely submerged when it falls to the swamp floor where it will rot or oxidize rather than be preserved.



Eustatic or global sea level fluctuations were common and regular throughout the second half of the Carboniferous Period. Coal seams are found in layers alternating between marine and non-marine rocks, indicating cycles of coastal transgressions and regressions played an important role in coal formation. The Carboniferous-age rocks of the Eastern U.S. and Europe record regular cycles of advancing and retreating seas; where beds of coal, shale, limestone, and sandstones were deposited in more or less repetitive sequences. These sequences, called cyclothems, have been well-documented, particularly during the Late-Upper Carboniferous.

Although several factors influenced the timing and distribution of these cyclothems, it is generally believed that cycles of rising and subsiding sea levels were the primary cause. These changes appear to have been global in scope — brought about by repetitive cycles of ice expansion, then ice melting, during the Carboniferous Ice Age.

How Coal Forms
Although most of the Carboniferous-age coal seams of West Virginia are on average less than 4 feet in thickness, they occasionally can be as thick as 25 feet. The bituminous coal beds of North America and Europe were laid down in swamps along coastal environments which are often dominated by meandering river deltas. Because these deltas were always moving and changing, the distribution and thickness of individual coal beds tend to be variable, — sometimes erratic.

Coal seams are often comprised of distinct, mappable benches which laterally thicken and thin, merge and split apart, and often vary in physical properties like ash and sulfur based on their proximity to channel systems and marine shorelines at the time of deposition. There are many areas in the coalfields which contain few minable coals or no coals at all. But for the most part, individual seam horizons are remarkably persistent along great horizontal distances. So much so that the geologic formations of this time period are often best correlated by using the coal seams themselves as marker beds.

When conditions were right, accumulating dead plants formed peat beds which after burial were subjected to heat and pressure as additional sediment layers continued to accumulate and add weight. Several thousand feet of sediments were added during the geologic ages that followed. In the Appalachian Region, most of this rock overburden was subsequently removed by erosion.

During deep burial the peat undergoes coalification, which squeezes out up to 98% of the water and some of the volatile hydrocarbons. The older and more deeply-buried a coal seam is the less water and volatile matter it contains. The ratio of fixed carbon to volatile matter is used to determine a coal's rank. The higher the ratio, the higher its rank.

The lowest rank of coal is peat. Next comes lignite, then sub-bituminous, bituminous, and in tectonically active regions — anthracite. Coal beds of the Carboniferous Period are almost all ranked bituminous, or higher, because of their great age and the great burial depth and moderate tectonic forces that were applied since their deposition.

A bituminous coal bed 1 ft. thick may have required as much as 7-10 ft. of peat thickness to start with. The process of peat accumulation continues until terminated by an event like an invasion of a nearby river channel, a marine transgression, or unfavorable climate. Each time shorelines retreated coal swamps migrated with them, along vast deltas which received seemingly limitless supplies of sediment from the emerging Pangean mountain range to the southeast. Although these highlands may have rivaled the Himalayas in relief, they are now completely gone — eroded down to nothing by the relentless forces of wind and rain over geologic time.

Thanks to the Carboniferous Ice Age, and continental drift, coal occurs in relative abundance, and is mined today for a variety of energy, manufacturing, and medicinal purposes.

Today the Earth warms up and cools down in 100,000 year cycles. Geologic history reveals similar cycles were operative during the Carboniferous Period. Warming episodes caused by the periodic favorable coincidence of solar maximums and the cyclic variations of Earth's orbit around the sun are responsible for our warm but temporary interglacial vacation from the Pleistocene Ice Age, a cold period in Earth's recent past which began about 2 million years ago and ended (at least temporarily) about 10,000 years ago. And just as our current world has warmed, and our atmosphere has increased in moisture and CO_2 since the glaciers began retreating 18,000 years ago, so the Carboniferous Ice Age witnessed brief periods of warming and CO_2 enrichment.

Following the Carboniferous Period, the Permian Period and Triassic Period witnessed predominantly desert-like conditions, accompanied by one or more major periods of species extinctions. CO_2 levels began to rise during this time because there was less erosion of the land and therefore reduced opportunity for chemical reaction of CO_2 with freshly exposed minerals. Also, there was significantly less plant life growing in the proper swamplands to sequester CO_2 through photosynthesis and rapid burial.

It wasn't until Pangea began breaking up in the Jurassic Period that climates became moist once again. Carbon dioxide existed then at average concentrations of about 1200 ppm, but has since declined. Today, at 380 ppm our atmosphere is CO_2 impoverished, although environmentalists, certain political groups, and the news media would have us believe otherwise.

What will our climate be like in the future? That is the question scientists are asking and seeking answers to currently. The causes of global warming and climate change are today being popularly described in terms of human activities. However, climate change is something that happens constantly on its own. If humans are in fact altering Earth's climate with our cars, electrical power plants, and factories, these changes must be larger than the natural climate variability in order to be measurable. So far the signal of a discernible human contribution to global climate change has not emerged from this natural variability or background noise.

Understanding Earth's geologic and climate past is important for understanding why our present Earth is the way it is, and what Earth may look like in the future. The geologic information locked up in the rocks and coal seams of the Carboniferous Period are like a history book waiting to be opened. What we know so far is merely an introduction. It falls on the next generation of geologists, climatologists, biologists, and curious others to continue the exploration and discovery of Earth's dynamic history — a fascinating and surprising tale, written in stone.

Source: Monte Hieb, March 21, 2009
http://www.geocraft.com/WVFossils/Carboniferous_climate.html

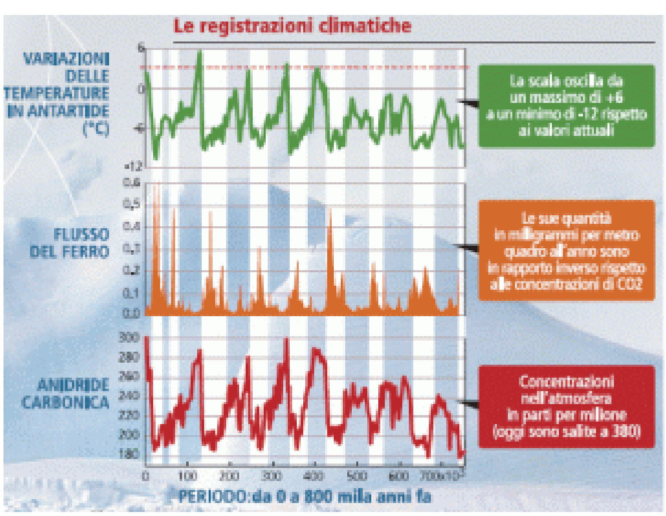
Two-Mile-Deep Antarctic Ice Core Reveals Stupidity of AGW Catastrophism

The extraordinary conclusions of the Epica 2008 Quaternary Climate scientific conference (Nov 10-13, Venice, Italy) have elicited little interest in the media. It's anybody's guess if that's related to the fact that those results clearly and evidently show that:

1. the Earth's climate has been wildly oscillating between cold and warmth for at least 800,000 years, long before any sizable man-made intervention
2. during that period, the record minimum has been reached around 20,000 years ago (10C less than today's); that's before agriculture
3. the record maximum still belongs to around 120,000 years ago (+5 C more than today's); and that's before agriculture, too
4. the concentrations of CO_2 have depended on the amounts of iron in dust, with higher availability of iron resulting in lower amounts of atmospheric CO_2
5. and whilst temperatures have been at times warmer than today's, and at other times much colder, corals, mammals, birds, trees and the rest of the biosphere have chugged along nicely (in a relative way)

AGW-related catastrophism is going the way of the dodo. Alas, so far there's been no space to mention that in the vast majority of mainstream news media.

I have to admit, I would have known nothing about Epica 2008 were it not for Italian climate blog Climate Monitor"by Major Guido Guidi, weather and climate expert of the Italian Air Force. One can only thank Guidi, and Turin newspaper La Stampa's science supplement Tuttoscienze for deciding to mention the results of the analysis of a 3,230-meter ice core extracted at Dome C, 75S 123E's Concordia Base in Antarctica. That's the deepest ice core ever extracted.



Dome C ice-core results

In the picture: green is for temperature variations in degrees C; orange is for iron fluxes, in milligrams per square meter; red is for CO_2 concentrations in ppmv; years are in thousands before-present (B.P.)

According to the data, Earth has gone through 8 ice ages and 8 warm ages during the past 800,000 years. Barbante says, "We are now in one of the warm phases. It started 10,000 years ago and, comparing it to what there's been [in the past], it can be seen that it's anomalous, because it has been lasting a long time and temperatures have been very stable." Still, Beccaria points out that between 120,000 and 100,000 years ago, temperatures have been up to 5C warmer than today's, at the upper end that is of the IPCC's more catastrophic scenarios (or predictions). And just 20,000 years ago, the Earth was up to 10C colder (a negative record for the past 800,000 years, apparently). Barbante again: "The cyclical nature [of temperatures] provides us with the right perspective concerning the climatic changes observed at the moment: if we don't make the effort towards reaching a better understanding of the natural mechanisms [of climate change], it will be useless to keep trying to patch up predictions on what will happen in a century or two."

Paleoclimatologists to the rescue then, cajoling to recover at least part of their past relevance after being outclassed by climate modelers as the main reference group able to talk to the politicians. But there is more (apart from the confirmation of human-related pollution, in terms of methane, nitrogen oxides, chloride, sulfates, nitrates, and heavy metals). Barbante: "in the core we have measured…the flux of iron in the dust. [Iron] is a biologically-active metal, as it underlies…the conversion of CO_2 and nutrients like nitrogen and phosphorus in organic compounds. [We know now that] during glacial intervals iron increases and the biological pump works at its best, whilst during the interglacials like today's, that process is less efficient and CO_2 increases."

With iron availability near zero at the moment, it is therefore little surprise that CO_2 has been increasing, admittedly to record levels compared to the past 800,000 years. In other words it may be not just a matter of human emissions, but also of momentarily inefficient present day carbon sinks. Beccaria concludes that next step is to investigate the warm periods in order to find clues about the present situation.

For me the above demonstrates how stupid AGW catastrophism like Mark Lynas', Al Gore's and Jim Hansen's is and has been for many years. Stupid in the sense of hurting the rest of the world (by impeding an appropriate analysis of the history of climate change and past warm phases, thereby spreading blindness towards probable causes and possible effects); whilst hurting its own cause (by convincing people the magnitude of the challenge is so great, there isn't much that can be done). The most they can show is a cursory series of conferences leading to little promises for 10 years in the future, and grand promises for 50 years (so Governments have only 49 years to renege on their big promises). On second thought, that may truly be a good thing.

Source: Maurizio Morabito, November 16, 2008
http://omniclimate.wordpress.com/2008/11/16/two-mile-deep-antarctic-ice-core-reveals-stupidity-of-agw-catastrophism/

Sea Ice at Lowest Level in 800 Year Near Greenland

New research, which reconstructs the extent of ice in the sea between Greenland and Svalbard from the 13th century to the present, indicates that there has never been so little sea ice as there is now. The research results from the Niels Bohr Institute, among others, are published in the scientific journal, *Climate Dynamics.*

There are of course neither satellite images nor instrumental records of the climate all the way back to the 13th century, but nature has its own 'archive' of the climate in both ice cores and the annual growth rings of trees and we humans have made records of a great many things over the years — such as observations in the log books of ships and in harbour records. Piece all of the information together and you get a picture of how much sea ice there has been throughout time.

Modern research and historic records

"We have combined information about the climate found in ice cores from an ice cap on Svalbard and from the annual growth rings of trees in Finland and this gave us a curve of the past climate," explains Aslak Grinsted, geophysicist with the Centre for Ice and Climate at the Niels Bohr Institute at the University of Copenhagen. In order to determine how much sea ice there has been, the researchers needed to turn to data from the logbooks of ships, which whalers and fisherman kept of their expeditions to the boundary of the sea ice. The ship logbooks are very precise and go all the way back to the 16th century. They relate at which geographical position the ice was found. Another source of information about the ice are records from harbors in Iceland, where the severity of the winters have been recorded since the end of the 18th century.

By combining the curve of the climate with the actual historical records of the distribution of the ice, researchers have been able to reconstruct the extent of the sea ice all the way back to the 13th century. Even though the 13th century was a warm period, the calculations show that there has never been so little sea ice as in the 20th century.

In the middle of the 17th century there was also a sharp decline in sea ice, but it lasted only a very brief period. The greatest cover of sea ice was in a period around 1700-1800, which is also called the 'Little Ice Age'.

"There was a sharp change in the ice cover at the start of the 20th century," explains Aslak Grinsted. He explains, that the ice shrank by 300.000 km2 in the space of ten years from 1910-1920. So you can see that there have been sudden changes throughout time, but here during the last few years we have had some record years with very little ice extent.

"We see that the sea ice is shrinking to a level which has not been seen in more than 800 years," concludes Aslak Grinsted.

Source: Science Daily, July 2, 2009
http://www.sciencedaily.com/releases/2009/07/090701102900.htm

Chilean Glaciers Melting at Unprecedented Rates

NASA Scientists Reveal Patagonia Glaciers Are Losing Ice Mass In Higher Zones

The latest research expedition to the Southern Patagonia Ice Field revealed that alpine glaciers in the Chilean and Argentine Andes are disappearing at much faster rates than previously anticipated by the scientific community. A preliminary analysis by a team of scientists from NASA and Chile's Valdivia-based Center of Scientific Studies (CECS), which commenced an expedition to the Ice Field in October 2008, sheds light on the alarming speed at which the glaciers are depleting.

Grey's Glacier meets Lake Grey in Patagonia's Torres del Paine National Park

The scientists discovered that the masses of ice in the Patagonia are melting in larger proportions and in much higher alpine zones than in any other part of the world, including Alaska and the Himalayas. Glacier ice accounts for around 75 percent of the world's fresh water. "The loss of ice mass in the higher zones is the really new phenomenon," said Gino Casassa, a CECS glaciologist. "At least this is what we are seeing with the preliminary results which we have just received."

Until recently, it was believed that glacial loss occurred from lower areas, and that snowfall on the higher sections of glaciers would compensate for loss of ice at lower altitudes. "One hypothesis we put forward was that there could be a positive balance of ice in the high zones because of higher rates of snowfall in these areas," said Casassa.

But with ice thinning high up and down low, too, loss in glacial mass in Patagonia is likely to be much greater than what has previously been calculated by scientists. The new findings are also curious because they contradict some former studies.

For example, a previous study found that the Chilean glaciers Trinidad and Pio XI (the biggest glacier in the southern hemisphere outside of Antarctica) had advanced instead of receded, while the Perito Moreno glacier in the Los Glaciares National Park in southern Argentina had maintained a volume balance. Between 1944 and 1986 glacial ice in the Southern Patagonia Ice Field was recorded as retreating at an average of 57 meters per year.

Most of Chile's 3,500 identified glaciers can be found in the Patagonia Region. And most have experienced significant losses in volume and surface area due to climate change and are in danger of disappearing altogether. "This loss contributes significantly to sea levels," noted Casassa. "Between 1995 and 2000, Patagonian glaciers made up nine percent of the total glacier contribution to sea levels."

The shrinking mass of the Patagonian glaciers, especially the accelerated melting of the sections of glaciers in lower altitudes, was established by 1996 satellite studies and the more recent work of Japanese scientists and Eric Rognot from NASA in 2003. The Southern Patagonia Ice Field has the third largest concentration of continental ice, after Antarctica and Greenland. Many of the Patagonia glaciers are protected under different National Parks, including Torres del Paine and Bernardo O'Higgins in Chile, and Los Glaciares in Argentina.

The higher temperatures associated with glacier meltdowns and climate change are largely caused by CO_2 or "greenhouse gas" emissions. Chile's failure to develop a sensible renewable energy policy has resulted in a green light to highly-polluting coal and diesel fuel energy production. State authorities confirm that the nation's CO_2 emissions will quadruple in the next 20 years if no mitigating actions are taken.

Source: El Mercurio, Natalie Muller, Santiago Times, Tuesday, June 23, 2009
http://www.santiagotimes.cl/santiagotimes/index.php/2009062216532/news/environmental-news/chilean-glaciers-melting-at-unprecedented-rates.html

Chaotic World of Climate Truth

Do images of climate-related chaos distort the scientific truth?

As activists organized by the group Stop Climate Chaos gather in London to demand action, one of Britain's top climate scientists says the language of chaos and catastrophe has got out of hand. Climate change is a reality, and science confirms that human activities are heavily implicated in this change. But over the last few years a new environmental phenomenon has been constructed in this country - the phenomenon of catastrophic climate change. It seems that mere climate change was not going to be bad enough, and so now it must be catastrophic to be worthy of attention.

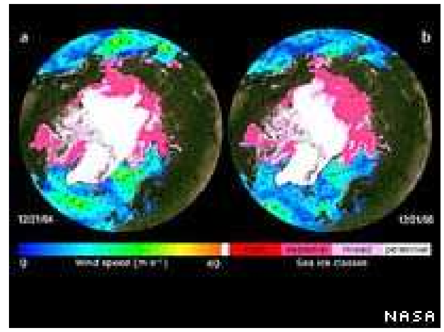
The increasing use of this pejorative term - and its bedfellow qualifiers chaotic, irreversible, rapid - has altered the public discourse around climate change. This discourse is now characterized by phrases such as climate change is worse than we thought, that we are approaching irreversible tipping in the Earth's climate, and that we are at the point of no return.

I have found myself increasingly chastised by climate change campaigners when my public statements and lectures on climate change have not satisfied their thirst for environmental drama and exaggerated rhetoric. It seems that it is we, the professional climate scientists, who are now the (catastrophe) skeptics. How the wheel turns.

Boarding the bandwagon

Some recent examples of the catastrophists include Tony Blair, who a few weeks back warned in an open letter to EU head of state, "We have a window of only 10-15 years to take the steps we need to avoid crossing a catastrophic tipping point." Today, a mass demonstration in Trafalgar Square will protest, aiming to stop climate chaos - the name for a coalition of environmental activists and faith-based organizations. The BBC broadcast in May its Climate Chaos season of programs. There is even a publicly-funded science research project called Rapid.

Why is it not just campaigners, but politicians and scientists too, who are openly confusing the language of fear, terror, and disaster with the observable physical reality of climate change, actively ignoring the careful hedging which surrounds science's predictions? James Lovelock's book, *The Revenge of Gaia,* takes this discourse to its logical endpoint - the end of human civilization itself.



Scenarios of climate change are significant enough without invoking catastrophe and chaos as unguided weapons

What has pushed the debate between climate change scientists and climate skeptics to now being between climate change scientists and climate alarmists? I believe there are three factors now at work.

First, the discourse of catastrophe is a campaigning device being mobilized in the context of failing UK and Kyoto Protocol targets to reduce emissions of carbon dioxide. The signatories to this UN protocol will not deliver on their obligations. This bursting of the campaigning bubble requires a determined reaction to raise the stakes - the language of climate catastrophe nicely fits the bill. Hence we now have the militancy of the Stop Climate Chaos activists and the megaphone journalism of the Independent newspaper, with supporting rhetoric from the prime minister and senior government scientists. Others suggest that the sleeping giants of the Gaian Earth system are being roused from their millennia of slumber to wreck havoc on humanity.

Second, the discourse of catastrophe is a political and rhetorical device to change the frame of reference for the emerging negotiations around what happens when the Kyoto Protocol runs out after 2012. The Exeter conference of February 2005 on "Avoiding Dangerous Climate Change" served the government's purposes of softening-up the G8 Gleneagles summit through a frenzied week of "climate change is worse than we thought" news reporting and group-think. By stage-managing the new language of catastrophe, the conference itself became a tipping point in the way that climate change is discussed in public.

Third, the discourse of catastrophe allows some space for the retrenchment of science budgets. It is a short step from claiming these catastrophic risks have physical reality, saliency, and are imminent, to implying that one more "big push" of funding will allow science to quantify them objectively. We need to take a deep breath and pause.

Fear and Terror

The language of catastrophe is not the language of science. It will not be visible in next year's global assessment from the world authority of the Inter-governmental Panel on Climate Change (IPCC). To state that climate change will be catastrophic hides a cascade of value-laden assumptions which do not emerge from empirical or theoretical science. Is any amount of climate change catastrophic? Catastrophic for whom, for where, and by when? What index is being used to measure the catastrophe? The language of fear and terror operates as an ever-weakening vehicle for effective communication or inducement for behavioral change.

This has been seen in other areas of public health risk. Empirical work in relation to climate change communication and public perception shows that it operates here too. Framing climate change as an issue which evokes fear and personal stress becomes a self-fulfilling prophecy. By "sexing it up" we exacerbate, through psychological amplifiers, the very risks we are trying to ward off.

The language of politicians can be as strong as that of campaigners

The careless (or conspiratorial?) translation of concern about Saddam Hussein's putative military threat into the case for Weapons of Mass Destruction has had major geopolitical repercussions. We need to make sure the agents and agencies in our society which would seek to amplify climate change risks do not lead us down a similar counter-productive pathway.

The IPCC scenarios of future climate change - warming somewhere between 1.4 and 5.8 Celsius by 2100 - are significant enough without invoking catastrophe and chaos as unguided weapons with which forlornly to threaten society into behavioral change. I believe climate change is real, must be faced and action taken. But the discourse of catastrophe is in danger of tipping society onto a negative, depressive and reactionary trajectory.

Source: BBC News, Mike Hulme, Professor of Environmental Sciences at the University of East Anglia, and Director of the Tyndall Centre for Climate Change Research, November 4, 2006
http://news.bbc.co.uk/2/hi/science/nature/6115644.stm

Media Attacked for Climate Porn

Apocalyptic visions of climate change used by newspapers, environmental groups and the UK government amount to "climate porn", a think-tank says.


The media excessively dramatize climate change impacts, says IPPR

The report from the Labour-leaning Institute for Public Policy Research (IPPR) says over-use of alarming images is a "counsel of despair". It says they make people feel helpless and says the use of cataclysmic imagery is partly commercially motivated. However, newspapers have defended their coverage of a "crucial issue". The IPPR report also criticizes the reporting of individual climate-friendly acts as "mundane, domestic and uncompelling". "The climate change discourse in the UK today looks confusing, contradictory and chaotic," says the report, entitled Warm Words. "It seems likely that the overarching message for the lay public is that in fact, nobody really knows."

Alarm and rhetoric

IPPR's head of climate change Simon Retallack, who commissioned the report from communication specialists Gill Ereaut and Nat Segnit, said: "We were conscious of the fact that the amount of climate change coverage has increased significantly over the last few years, but there had been no analysis of what the coverage amounted to and what impact it might be having." They analyzed 600 newspaper and magazine articles, as well as broadcast news and adverts.

Coverage breaks down, they concluded, into several distinct areas, including:

- Alarmism, characterized by images and words of catastrophe
- Settlerdom, in which "common sense" is used to argue against the scientific consensus
- Rhetorical skepticism, which argues the science is bad and the dangers hyped
- Techno-optimism, the argument that technology can solve the problem

Publications said often to take a "skeptical" line included the Daily Mail and Sunday Telegraph. Into the "alarmist" camp the authors put articles published in newspapers such as the Independent, Financial Times and Sunday Times, as well as statements from environmental groups, academics including James Lovelock and Lord May, and some government programs.

"It is appropriate to call [what some of these groups publish] 'climate porn', because on some level it is like a disaster movie," Mr. Retallack told the BBC News website. "The public become disempowered because it's too big for them; and when it sounds like science fiction, there is an element of the unreal there."

Horror film

No British newspaper has taken climate change to its core agenda quite like the Independent, which regularly publishes graphic-laden front pages threatening global meltdown, with articles inside continuing the theme. A recent leader, commenting on the heat wave then affecting Britain, said: "Climate change is an 18-rated horror film. This is its PG-rated trailer. "The awesome truth is that we are the last generation to enjoy the kind of climate that allowed civilization to germinate, grow and flourish since the start of settled agriculture 11,000 years ago."

Ian Birrell, the newspaper's deputy editor, said climate change was serious enough to merit this kind of linguistic treatment. "The Independent led the way on campaigning on climate change and global warming because clearly it's a crucial issue facing the world," he said. "You can see the success of our campaign in the way that the issue has risen up the political agenda." Mr. Retallack, however, believes some newspapers take an alarmist line on climate change through commercial motives rather than ideology. "Every newspaper is a commercial organization," he said, "and when you have a terrifying image on the front of the paper, you are likely to sell more copies than when you write about solutions." Mr. Birrell denied the charge. "You put on your front page what you deem important and what you think is important to your readers," he said. "If our readers thought we put climate change on our front pages for the same reason that porn magazines put naked women on their front pages, they would stop reading us. " And I disagree that there's an implicit 'counsel of despair', because while we're campaigning on big issues such as ice caps, we also do a large amount on how people can change their own lives, through cycling, installing energy-efficient lighting, recycling, food miles; we've been equally committed on these issues."

Small is not beautiful

The IPPR report acknowledges that the media, government and NGOs do discuss individual actions which can impact greenhouse gas emissions, such as installing low-energy light bulbs. But, it says, there is a mismatch of scale; a conclusion with which Solitaire Townsend, MD of the sustainable development communications consultancy Futerra, agrees. "The style of climate change discourse is that we maximize the problem and minimize the solution," she said. "So we use a loud rumbling voice to talk about the challenge, about melting ice and drought; yet we have a mouse-like voice when we talk about 'easy, cheap and simple' solutions, making them sound as tiny as possible because we think that's what makes them acceptable to the public. "In fact it makes them seem trivial in relation to the problem." Mr. Retallack believes his report contains important lessons for the government as it attempts to engage the British public with climate change. "The government has just put £12m into climate change communication initiatives," he said, "including teams which will work at the local level. "It's vital that this motivates and engages the public."

Source: BBC News, Richard Black, August 2, 2006
http://news.bbc.co.uk/2/hi/science/nature/5236482.stm.

The Climate Change Debate:
The History and the Forefathers

To many of us it seems as though the climate change debate is only a recent phenomena, and indeed, we have been positively bombarded by the media coverage of global warming in the past decade. Surprisingly, though, climate change speculation and study have been taking place for quite some time. In his recently published article in Weatherwise, a non-profit weather magazine, professor of geological sciences and contributing editor Randy Cerveny points out that some unexpected characters were just as concerned with weather change as we are now.

Any self- respecting history buff might guess that the foremost of our founding fathers to study climate change would have been Benjamin Franklin. It all adds up—he discovered electricity, invented bifocals, and constructed the first lightning rod. However, although Franklin was an outspoken student of weather and nature, Cerveny classifies none other than Noah Webster, lexicographer and founder of the modern Merriam- Webster Dictionary, as one of the most strident investigators on the subject of early American climate change.

In his intriguing Noah Webster: Lexicographer, Climatologist, Professor Cerveny points out the low and high points of Webster's career studying climate change. The lexicographer had many rivals in the scientific field, among whom were Thomas Jefferson and Harvard professor Samuel Williams, who hypothesized that local weather patterns changed with the colonization of American settlements as forest was cut down and converted to fields used for crop production. Webster built on this concept when he noted that "the clearing of lands opens them to the sun, their moisture is exhaled, they are more heated in summer, but more cold in winter near the surface; the temperature becomes unsteady, and the seasons irregular." Among his successes in climate change study also include his prediction that orbital changes of the earth alter long- term climate, a theory he anticipated, notes Cerveny, almost 200 years before it became known as fact.

Source: ENN: Environmental News Network, July 1, 2009, M. Molendyke
http://www.enn.com/search/?q=the+climate+change+debate