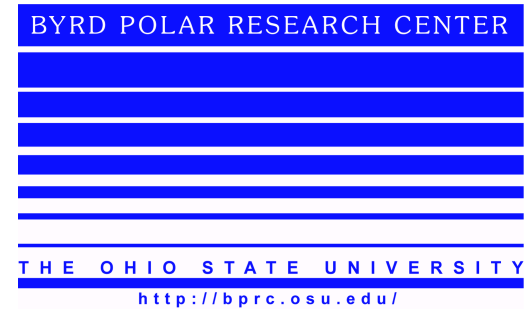




Introducing a Free DVD about Climate Change

Carol Landis, Education Outreach Specialist

Byrd Polar Research Center @ Ohio State

CLN: March 8, 2011

Understanding **Global** **Climate** **Change**

- (1) Looking at Earth as a System
- (2) Earth's Grand Cycles
- (3) Energy in the Earth System
- (4) Historical Perspective
- (5) Remote Sensing
- (6) Glacial Evidence
- (7) Meteorological Evidence
- (8) Ice Core Evidence
- (9) Oceanographic Evidence
- (10) Biological Evidence



Written and Created by
Mark Maley
Ron Pilatowski

Foreword

Selected
References

Glossary

Quit

Chapter 1: Looking at Earth as a System

(1.1) A Systems Approach to Look at Earth

2

A **system** is a series of parts or pieces that work together in an interconnected manner. These interacting parts or pieces can be thought of as **subsystems**. A system has inputs and outputs of energy and matter. You can think of the **inputs** as what is necessary to sustain the system or keep the system going. The **outputs** are what the system produces.



Glossary

(1.1) A Systems Approach to Look at Earth

5

It is important to understand the idea that a **positive feedback** doesn't necessarily produce an outcome that is "good", nor does a **negative feedback** mechanism end up producing an outcome that is "bad".



Glossary

Chapter 1, Continued

(1.1) A Systems Approach to Look at Earth

13

As our understanding of systems improves, it is possible to break systems down into subsystems. Each of these subsystems becomes a system in and of itself, with its own unique and identifiable inputs and outputs of energy and materials and their own feedback mechanisms. So, it is no surprise that we can recognize distinct subsystems of Earth: the [atmosphere](#), [hydrosphere](#), [cryosphere](#), [lithosphere](#), and [biosphere](#). Earth is also part of a bigger system, the [exosphere](#). In this sense, Earth functions as a subsystem of the exosphere. These subsystems are so complex that their study is often undertaken by a branch of science, with scientists who specialize in them. These scientific specialties will be addressed in the next section as we discuss Earth's subsystems in more detail.



Glossary

(1.3)

Systems Interactions

1



Each of Earth's [subsystems](#) does not exist alone. As part of the larger system, they are interconnected. So a change in one system can trigger changes in others. As you can see, these changes can affect other subsystems, resulting in changes that affect others, and so on.

Glossary

Quit

Main Menu

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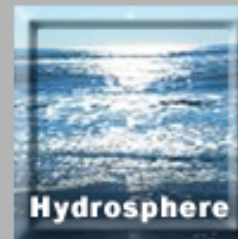


(1.3)

Systems Interactions

8

Earth's systems interact with each other continuously. An event in one system can **cause** an **effect** felt in another system. Read the statement between the two red boxes. Drag the appropriate systems into the "Cause" and "Effect" boxes. Click on "Check Answer" to see if you have set up the correct system interaction.



CAUSE



Cows produce methane.

EFFECT



Check
Answer

Reset



Quit

Main
Menu

Chapter
Menu



Chapter 2: Earth's Grand Cycles

Earth's Grand Cycles

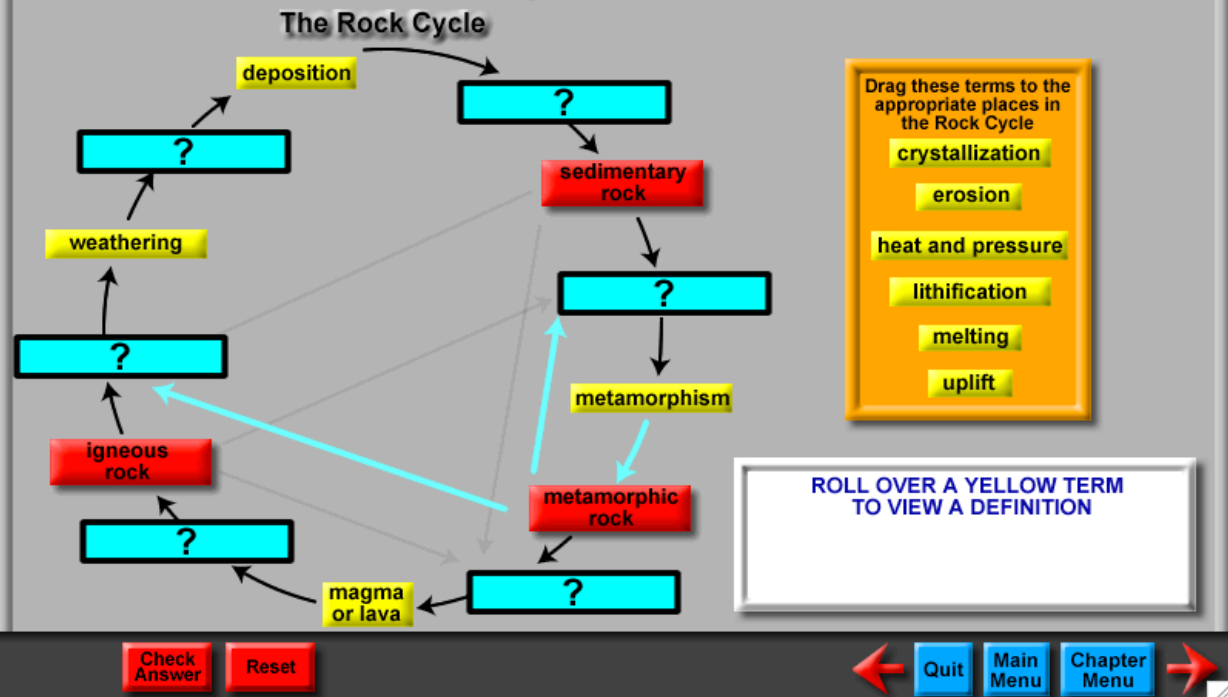
- (2.1) What are Grand Cycles?
- (2.2) Composition of the Atmosphere
- (2.3) The Water Cycle
- (2.4) The Nitrogen Cycle
- (2.5) The Sulfur Cycle
- (2.6) The Phosphorus Cycle
- (2.7) The Carbon Cycle
- (2.8) The Milankovitch Cycles
- (2.9) Checking Your Understanding

(2.1)

What are Grand Cycles?

3

Below is a model of the rock cycle. It describes the formation of rocks and movement of rock material within the Earth System. Some of the terms associated with this diagram are missing. Drag the terms into the proper location in the rock cycle and then click on "Check Answer." You'll have three chances to get the terms in the correct locations.



Chapter 2, Continued

(2.8)

The Milankovitch Cycles

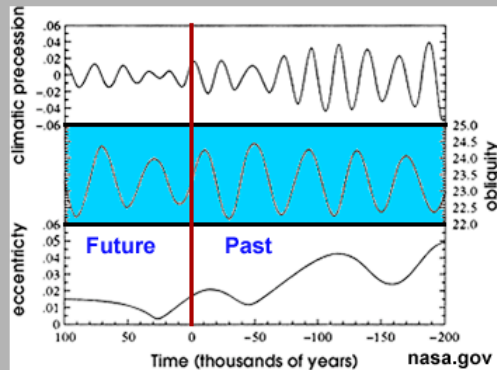
7

Look at the graph below. Actually, it includes three graphs: a graph of precession, obliquity, and eccentricity. Notice the time scale for the graphs. The vertical red line represents present time. To the right of the red line is the past, and to the left of the line is the future. The duration of each of the cycles can be seen in the graphs.

Precession's period is about 26,000 years.

Obliquity's period is about 40,000 years.

Eccentricity's period is about 100,000 years.



Graphic from: <http://earthobservatory.nasa.gov/Features/Milankovitch/milanko>

Glossary

(2.9)

Checking Your Understanding

1/20

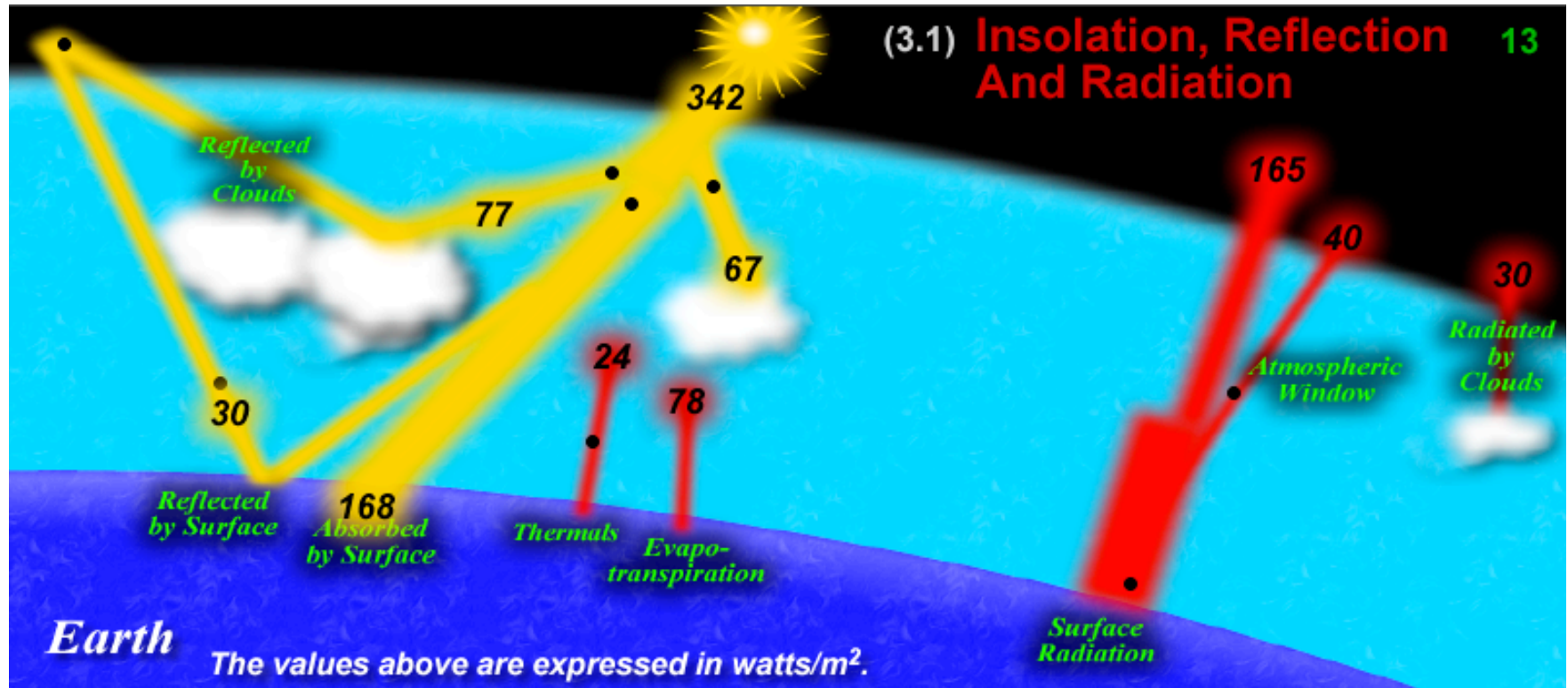
(You get ONE chance to answer this question correctly!)

Check all answers that may apply.

The most abundant gas in the atmosphere is ____.

- ☐ A. argon
- ☐ B. carbon dioxide
- ☐ C. nitrogen
- ☐ D. oxygen

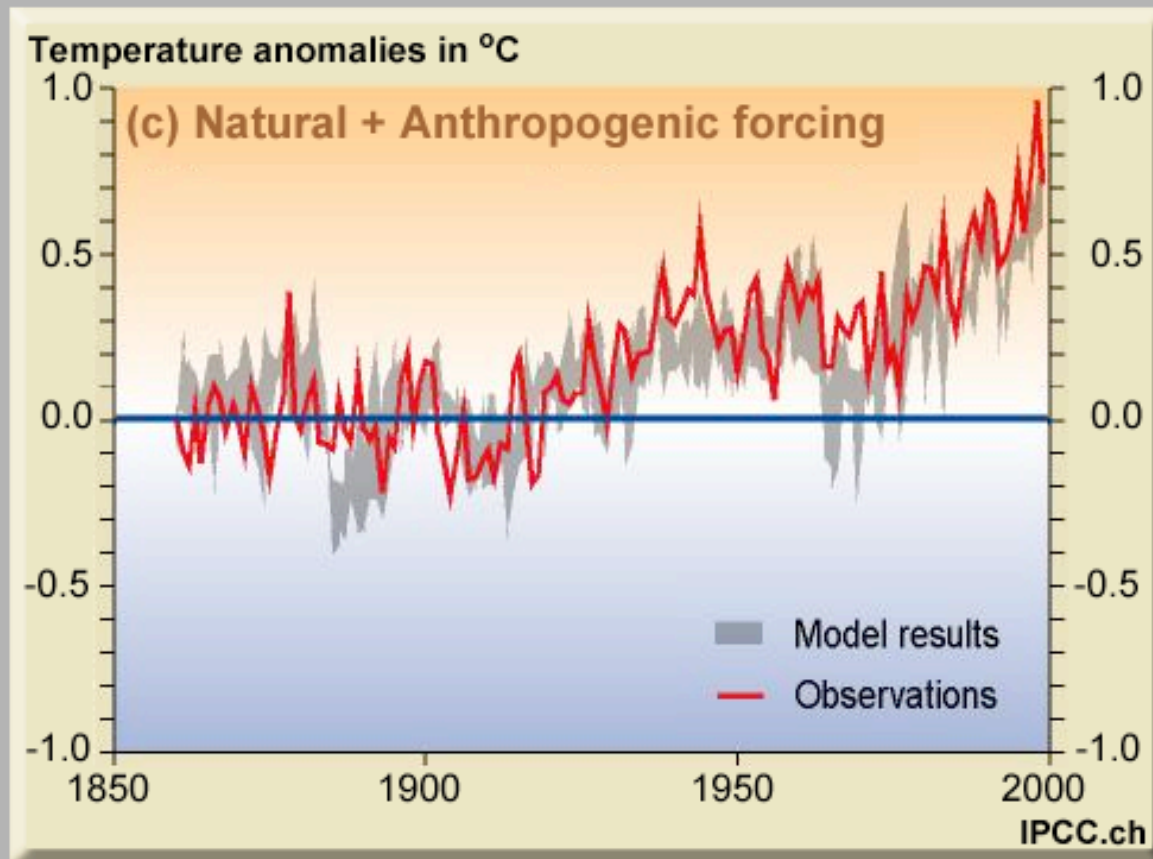
Chapter 3: Energy in the Earth System



Summary

- Earth absorbs energy from the Sun in the form of **shortwave radiation**.
- Clouds can absorb, reflect, and radiate energy.
- Some of this energy remains within the Earth system, and some of it is radiated.
- The radiated energy is in the form of **longwave radiation**, which is heat energy.

Another way of looking at climate change is to consider the impact of natural forcings compared to human ([anthropogenic](#)) forcings. Click on the three [forcing](#) buttons below to view three different graphs. Make note of what the gray and red lines signify. Natural forcings are factors that are found in nature that cause a change in the climate. These include [solar variability](#) and volcanoes. Anthropogenic forcings are the result of human activities.



Chapter 4: Historical Perspective

Historical Perspective

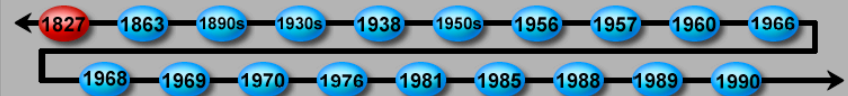
- (4.1) A Timeline of Global Climate Change Studies
- (4.2) The Importance of Oxygen
- (4.3) A Look at Climate Change Data
- (4.4) What was the temperature like in the past?
- (4.5) What were levels of some greenhouse gases in the past?
- (4.6) When did we see a change in greenhouse gas levels?
- (4.7) Checking Your Understanding

Quit

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(4.1) A Timeline of Global Climate Change Studies

2

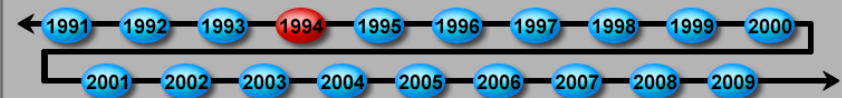


Frenchman Jean-Baptiste Fourier predicts an atmospheric effect keeping Earth warmer than it would normally be. He is the first to use a greenhouse analogy.



(4.1) A Timeline of Global Climate Change Studies

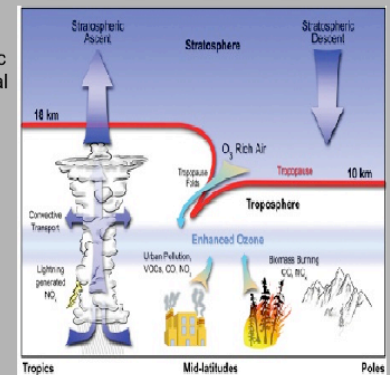
31



The IPCC's special report "Climatic Change 1994" indicated that increases in tropospheric (low-level) ozone in urban areas, and regional smog, especially in industrialized regions, added about 20% of the direct greenhouse gas effects globally, and more regionally.



<http://disc.sci.gsfc.nasa.gov/oceancolor/additional/science-focus/focus/images/LA-smog-2.jpg>



http://earthobservatory.nasa.gov/Features/Aura/Images/TroposphericOzone_HiRes.jpg



Glossary

Quit

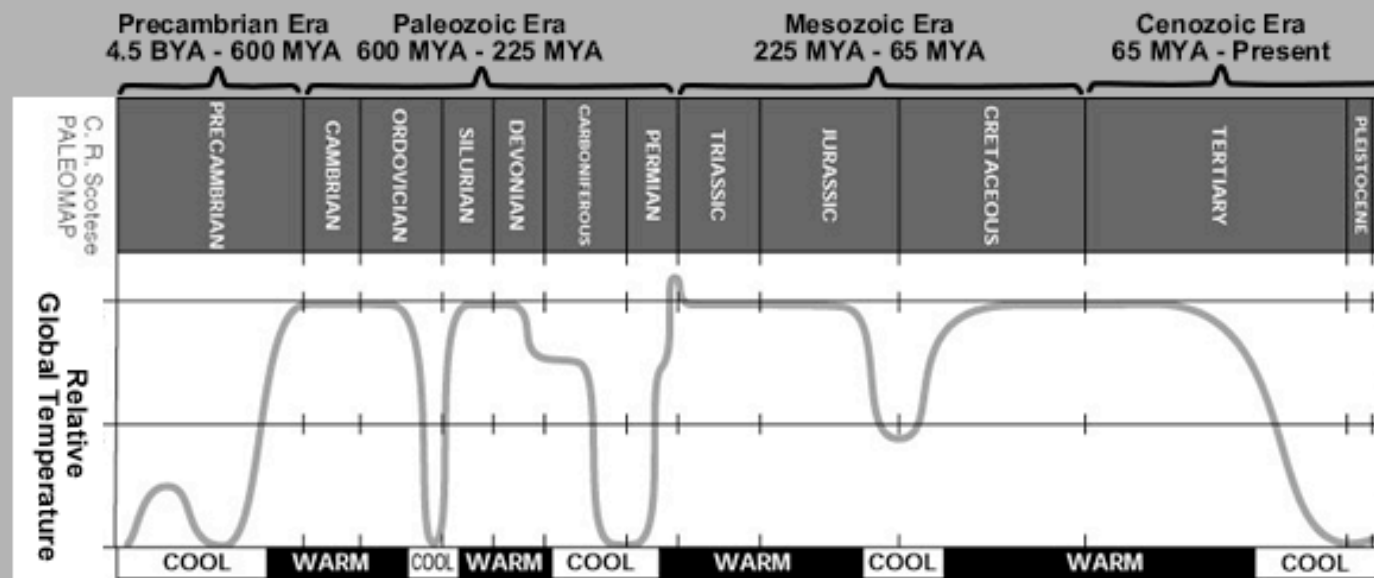
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Menu

(4.4) What was the temperature like in the past?

1

Much information in geology is based on proxy data. In the graph below, the author used geologic proxy data and instrumental record data to construct a temperature record for geologic time.

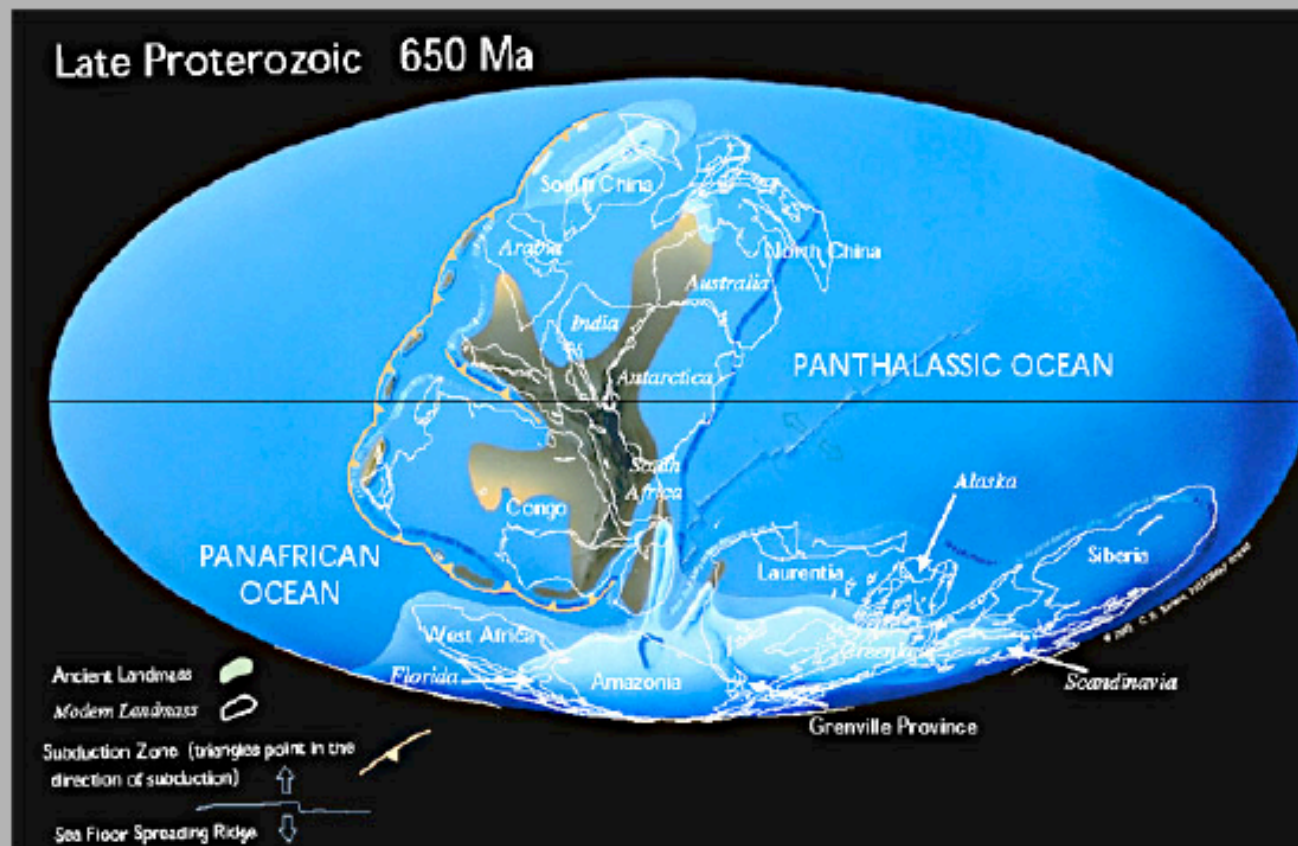


Relative Global Temperature Through Geologic Time
Modified from www.scotese.com

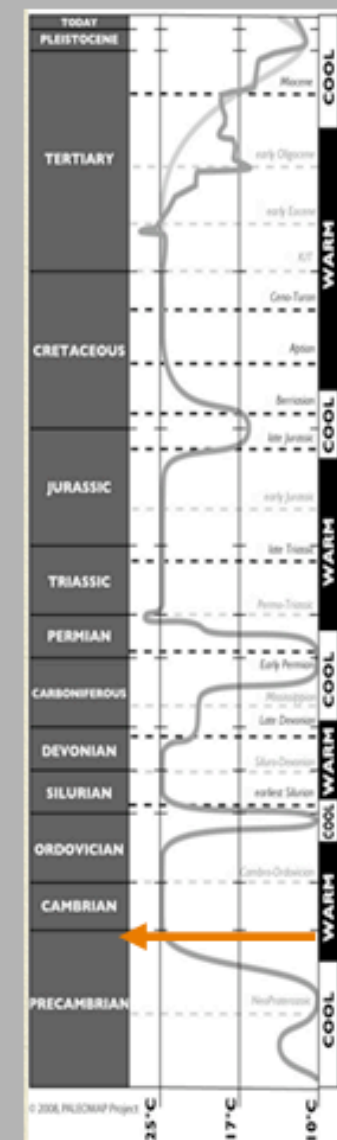
Click on the units of geological time in the illustration above to learn more about conditions on Earth at that time.

(4.4) Position of the Continents: Precambrian Era

1.1



The Late Precambrian was an "Ice House" World, much like the present-day.



Scotese, C.R., 2002, <http://www.scotese.com>

Types of Evidence

Understanding Global Climate Change

- (1) Looking at Earth as a System
- (2) Earth's Grand Cycles
- (3) Energy in the Earth System

- (5) Remote Sensing
- (6) Glacial Evidence
- (7) Meteorological Evidence
- (8) Ice Core Evidence
- (9) Oceanographic Evidence
- (10) Biological Evidence



Written and Created by
Mark Maley
Ron Pilatowski

Keyword

Selected
References

Glossary

Quit

Chapter 5: Remote Sensing

- (5.1) What is remote sensing?
- (5.2) Examples of Remote Sensing Tools
- (5.3) How is remote sensing used?
- (5.4) Case Study: Melt Lakes and Moulins
- (5.5) Checking Your Understanding

(5.2)

Examples of Remote Sensing Tools

2

Active remote sensing requires that the device used (onboard an airplane in the illustration below) must transmit some type of electromagnetic radiation. This radiation is directed to the surface below. Some of the radiation may be absorbed and some is reflected back toward a receiver (or sensor) onboard the aircraft or satellite (the “platform” carrying the instruments). Keep in mind, when viewing the illustration below, that all electromagnetic radiation travels at the speed of light. The velocity of the radiation in the illustration is reduced to permit easier understanding of this concept.



(5.2)

Examples of Remote Sensing Tools

4

Listed below are several platforms (objects such as ships, planes, and satellites) that carry instruments (such as cameras, sounders, radiometers) that are used by scientists to better understand the workings of the Earth system. Click on any to learn about them in more detail.

- AVHRR
- GRACE
- ICESAT
- LANDSAT
- MERIDIAN
- MODIS
- RADARSAT
- The Paths They Follow

Passive
Remote Sensing

Remote Sensing
Instruments & Platforms

Remote Sensing
Summary

Quit

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End

Chapter 6: Glacial Evidence

(6.3)

Alpine Glaciers

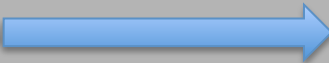
2

Click on the buttons below to observe how the glacier

● (6.1) What is a glacier?

● (6.2) What is happening to glaciers today?

● (6.3) Alpine Glaciers



● (6.4) Greenland

● (6.5) Antarctica

● (6.6) Checking Your Understanding

● Athabasca Glacier

● Gangotri Glacier

● Grinnell Glacier

● Mt. Kilimanjaro

● McCall Glacier

● Muir Glacier

● Qori Kalis Glacier

● Shepard Glacier

● Upsala Glacier

● Waxeggkees Glacier

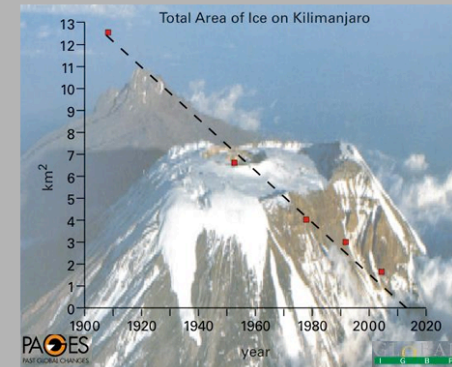
(6.3)

Alpine Glaciers

Mt. Kilimanjaro

9

Glaciologists who study this region predict that the glaciers found on Kilimanjaro will be gone by the year 2020, due to climate change.



Data: Lonnie Thompson
Alverson et al. Science 293:47

(6.3)

Alpine Glaciers

16

Summary

- Almost all alpine glaciers around the world are losing mass, decreasing in area and thickness.

- The graph to the right shows how the volume of glacial ice around the world is decreasing.

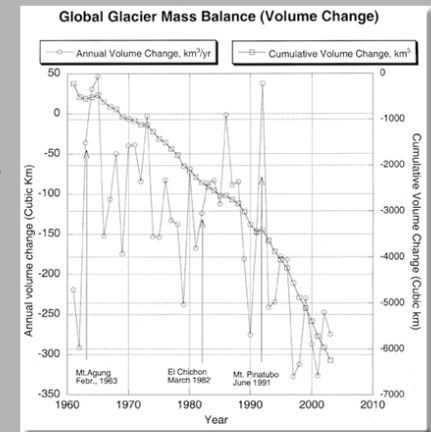


Image courtesy of Mark Dyurgerov
Institute of Arctic and Alpine Research,
University of Colorado, Boulder

(6.3)

Alpine Glaciers

Qori Kalis Glacier

12

Qori Kalis is part of the Quelccaya ice cap in the Andes Mountains in Peru. During the 1960s and 1970s, it retreated at a rate of approximately 4.7 meters (15.4 feet) per year. In the 21st century, its rate of retreat has increased to over 200 meters (672 feet) per year.



1978

nsidc.org

2004

photo by Lonnie G. Thompson
The Ohio State University

(6.3)

Alpine Glaciers

Qori Kalis Glacier

Qori Kalis is part of the Quelccaya ice cap in the Andes Mountains in Peru. During the 1960s and 1970s, it retreated at a rate of approximately 4.7 meters (15.4 feet) per year. In the 21st century, its rate of retreat has increased to over 200 meters (672 feet) per year.



2004

nsidc.org

1978

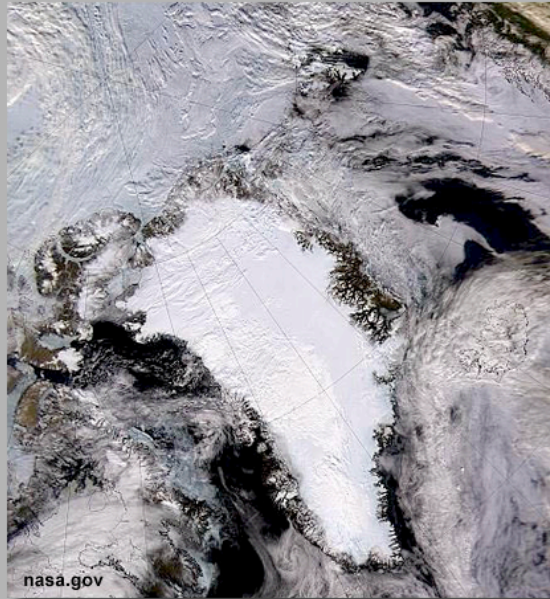
photo by Lonnie G. Thompson
The Ohio State University

Chapter 6: Glacial Evidence

(6.4)

Greenland

1



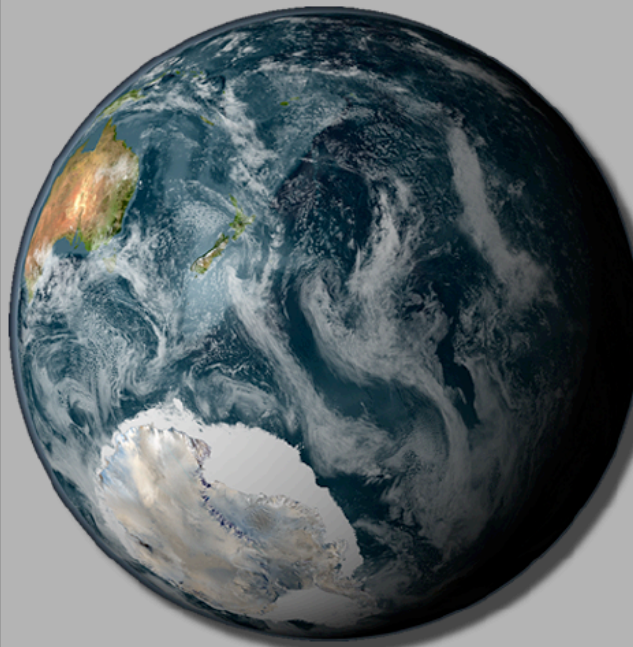
Click on any of the buttons below to learn more about glaciers in Greenland.

- History of Greenland
- Greenland's Ice
- Jakobshavn Glacier
- Helheim Glacier
- Kangerdlugssuaq Glacier

(6.5)

Antarctica

1



Click on any of the buttons below to learn more about Antarctica.

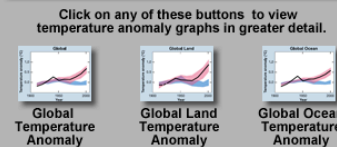
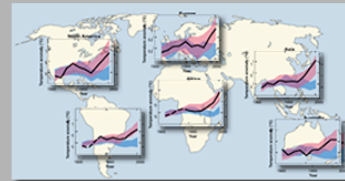
- Introduction to Antarctica
- Exploring Antarctica
- Antarctic Ice
- Larsen B
- Pine Island Glacier
- Lake Vostok
- Wilkins Ice Shelf

Chapter 7

Meteorological Evidence

- (7.1) An Introduction to Weather
- (7.2) What is Unique About the Polar Regions?
- (7.3) Global Temperature: Past, Present and Future
- (7.4) Change In the Composition of the Atmosphere
- (7.5) Observed Polar Climate Change Trends
- (7.6) The Ozone Hole and Climate Change Connection
- (7.7) Checking Your Understanding

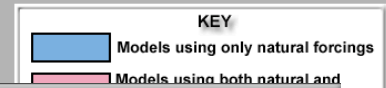
(7.3) Global Temperature: Past, Present, and Future ⁴



Natural **forcings** of Earth's climate are long-term processes that can affect climate. These may include things like oceanic circulation, composition of the atmosphere, solar activity, and changes in Earth's orbit.

Anthropogenic forcings are factors resulting from human activity. Large-scale deforestation and land-use changes may have changed the reflectivity and water use over a long period of time. Measurable changes in the concentration of greenhouse gases have also been attributed to human use of fossil fuels.

Computer models can calculate trends in temperature when factoring in natural and anthropogenic forcings. Click on the buttons to the left to view what these models indicate.

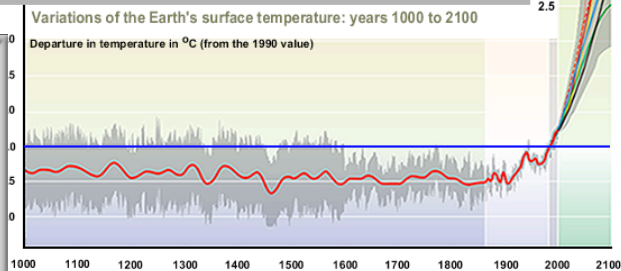


(7.3) Global Temperature: Past, Present, and Future ¹⁰

The graph has been extended to consider global temperatures in the future. Several projections are included in this section of the graph. Each of these lines represents a summary forecast from computer **models** when a defined set of assumptions are built into the equations.

Climate models are very complex and require much time for a supercomputer to complete the calculations. Once the calculations are completed, the computer generates output that climatologists will compare to previous climate records.

If the model and past climate records match, the climatologists have greater confidence that the model can reasonably project Earth's climate in future scenarios. Click forward and let's look at these future climate scenarios.



(7.3) Global Temperature: Past, Present, and Future ¹¹

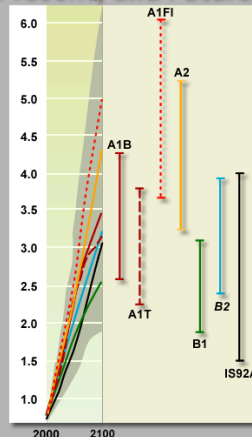
Seven scenarios were developed from the IPCC reports to predict the effects of climate change on temperature in the future. Under these scenarios, models indicate that Earth's temperature may increase anywhere from approximately 1.5 °C to 6.0 °C by the year 2100. No one knows which scenario will be more correct. Instead climatologists are looking at the factors responsible for the projected temperature change for each of the models.

Many climate models have been developed since the early 1990s. The IS92A model (1995) is one of these early climate change models. It offers a comparison between older models and modern models. Computer models will continue to improve as processing power improves and as interacting factors in Earth's climate system are better understood.

Click on the abbreviations in the yellow box below to learn about the assumptions that are built into each of these scenarios (representing possible levels of human activities) for our future.

CLICK ON THE CLIMATE MODEL SCENARIO BELOW TO VIEW ADDITIONAL INFORMATION.

A1B A1T A1FI A2 B1 B2



Chapter 8: Ice Core Evidence

Ice Core Evidence

- (8.1) What are ice cores? How are they obtained?
- (8.2) What can be learned from an ice core?
- (8.3) Checking Your Understanding

(8.1) What are ice cores? How are they obtained?

1

Introduction

Glaciers hold a record of past environmental information. A group of scientists, known as ice core [paleoclimatologists](#), travel to these glaciers in order to sample ice to retrieve these recorded data. The scientists obtain an [ice core](#) by drilling into the glacier and removing and storing the vertical cylinder of ice from the drill.



(8.1) What are ice cores? How are they obtained?

7

Now let's look at the entire process of obtaining ice cores in more detail. In this section, we'll focus on the work of one [paleoclimatologist](#), Dr. Lonnie G. Thompson's work focuses primarily on high altitude mountain glaciers around the world. He has spent more time above 19,000 feet elevation than anyone else alive today. Click on the green buttons below to see the techniques that he and his team have developed to obtain these [paleoclimate](#) records. The video clips in these sections are from the movie "Drilling", courtesy of Triri Productions.



Dr. Thompson standing in front of Qori Kalis Glacier in Peru. The glacier's elevation is 5,670 meters (18,602 feet.)



A short video about Dr. Thompson
Courtesy of CNN.com

- Preparing for the Expedition
- Getting to the Glacier
- Setting up Camp
- Drilling the Cores
- Transporting and Preserving the Cores
- Analyzing the Cores
- Watch the 24-Minute Movie "Drilling"

Chapter 9: Oceanographic Evidence

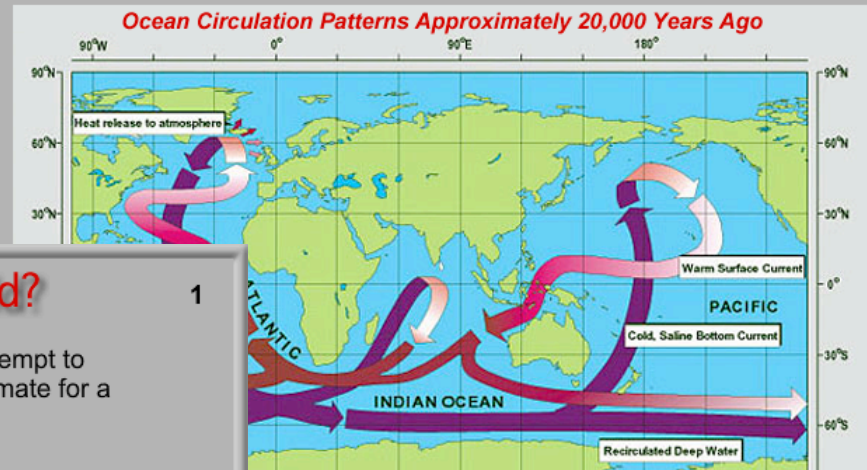
- (9.1) Historical Connections
- (9.2) Obtaining Core Samples in the Oceans
- (9.3) What the Fossils Say
- (9.4) What Dust and Mineral Grains Say
- (9.5) Icebergs
- (9.6) What Else Does A Sediment Core Yield?
- (9.7) Checking Your Understanding

(9.3)

What the Fossils Say

3

By identifying cold-water forams of the same age elsewhere in the oceans, paleoclimatologists were able to generate maps that showed where extremely cold waters existed at different points in Earth's history.

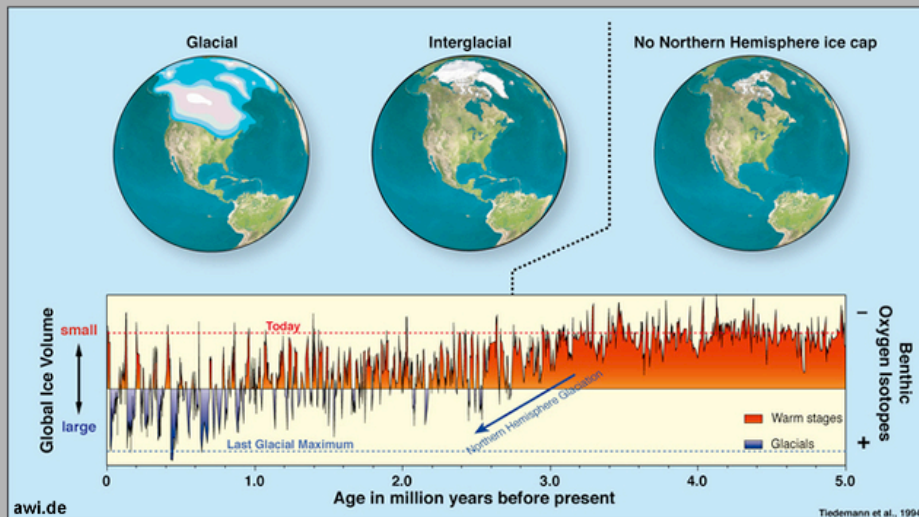


1

(9.6)

What Else Does A Sediment Core Yield?

Ocean sediment cores provide a valuable tool for scientists as they attempt to reconstruct Earth's climate history. These cores provide a record of climate for a considerable part of Earth's history, dating back millions of years.

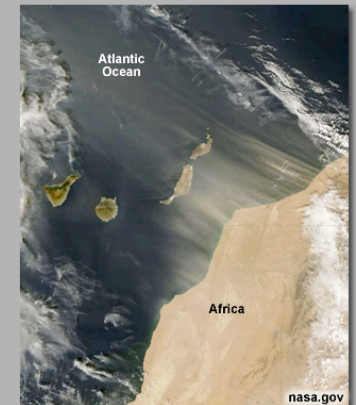
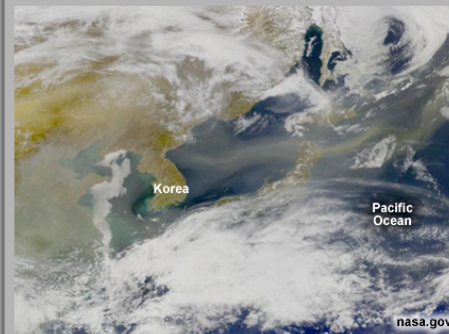


(9.4)

What Dust and Mineral Grains Say

1

Dust in ocean sediment cores can also tell paleoclimatologists about weather and patterns in ocean currents. Plumes of dust from the Sahara desert blow from Africa across the Atlantic to North and South America. Dust from the Mongolian desert and other deserts from Asia's interior blows toward the Pacific Ocean.



Chapter 10: Biological Evidence

- (10.1) Types of Biological Evidence
- (10.2) Direct Biological Evidence
- (10.3) Indirect Biological Evidence
- (10.4) What are Some Potential Trends for the Future?
- (10.5) Checking Your Understanding

(10.3) Indirect Biological Evidence

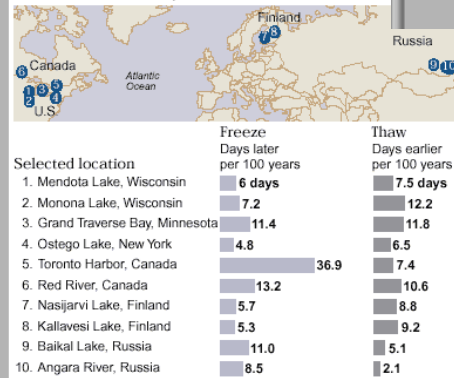
For the past 1,200 years, observations of the timing of peak cherry blossoms have been recorded in Japan. More modern records of "ice-in" and "ice-out" in the U.S.A, Canada, Finland, and Russia also provide evidence of climate history for those regions.



delaware.gov

Postponed freezes, earlier thaws

Researchers found evidence of global warming by studying data on freezing and thawing of 26 bodies of water. The study concludes that over the past 150 years, the freezing occurred an average of 8.7 days later and the thaw occurred about 9.8 days earlier. Here are selected results.



Source: Science

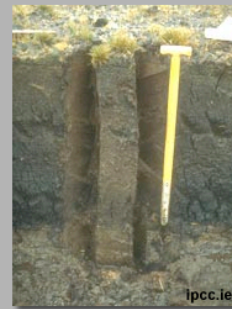
AP

(10.2)

Direct Biological Evidence

2

Several studies of pollen grains from these sources have yielded some interesting results. Fossil pollen recovered from peat in various places in the U.S. Midwest has revealed a rapid change in vegetation over a time span of at most 200 years. The vegetation changed from conifers like pines (which dominated the landscape near the glacial margin at the time of maximal glaciation) to oak trees, which can tolerate much drier, warmer conditions. Radiocarbon dating of these pollen grains provided additional evidence suggesting that a change in climate occurred much more quickly than most scientists had believed was possible.

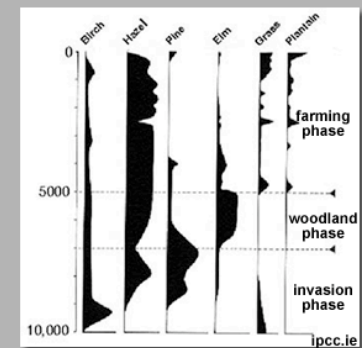


Sampling a bog for pollen



Sampled pollen from a bog

ipcc.ie



Graph representing pollen species over the last 10,000 years in Ireland

(10.4) What are Some Potential Trends for the Future?

1

Changes in the timing of biological events have the potential to adversely affect humans. The existence of many plants depends upon animal-mediated pollination. Flowering plants and their pollinators co-evolved. Factors that keep the timing of flowering in synchrony with the availability of particular animal pollinators are complex and unknown. It is quite possible that peak plant flowering times and pollinator availability could get out of synchrony - flowers would be opening before pollinating agents are available. This could have disastrous effects on agriculture.



wikipedia.org



wikipedia.org



wikipedia.org

Spanish Version

Comprendiendo el Cambio Climático Global

- (1) Un Modo Diferente de Comprender la Tierra.
- (2) Los Ciclos Grandes de la Tierra.
- (3) La Energía en el Sistema Global.
- (4) Perspectiva Histórica.
- (5) Percepción Remota.
- (6) Evidencia Glacial.
- (7) Evidencia Meteorológica.
- (8) Evidencia de la Corteza Congelada.
- (9) Evidencia Oceanográfica.
- (10) Evidencia Biológica.



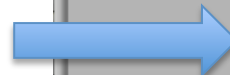
Escrit
Ma
Ro

PREFACIO

Referencias
Seleccionadas

Glosario

The captions/titles/labels were also translated, and the graphics were re-worked.



(1.3) INTERACCIONES DE LOS SISTEMAS

10

Los sistemas de la Tierra interactúan entre sí continuamente. Un evento en un sistema puede causar un efecto que a su vez afecta a otro sistema. Lean la aseveración entre los 2 cuadrados rojos. Arrastra el sistema apropiado hacia los cuadrados de "Causa y Efecto". Ahora haz clic en el botón "Verifica Respuesta" para que verifiques si haz establecido la interacción correcta del sistema.



Atmósfera



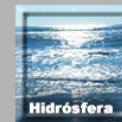
Biosfera



Criósfera



Exósfera



Hidrosfera



Litósfera

CAUSA

Arrastra el cuadro de CAUSA hasta aquí

Los volcanes emiten gases.

EFFECTO

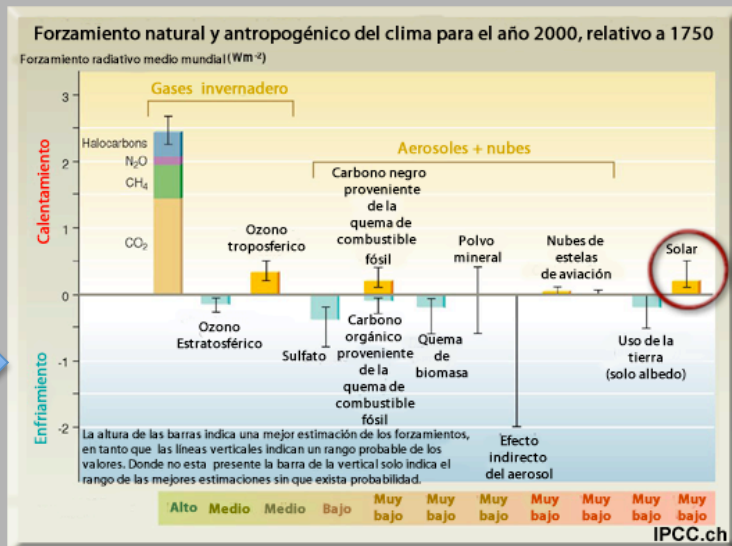
Arrastra el cuadro de efecto hasta aquí

(3.4)

La Variabilidad Solar

3

A pesar de la falta de una correlación convincente entre la radiación solar y la temperatura de la superficie terrestre, los cambios en la radiación solar pueden ser importantes para el promedio de temperatura de la superficie terrestre sobre periodos de tiempo más largos.



Conclusion

English version

- Over 5,000 DVDs (discs) given out; unknown numbers downloaded.
- Served as basis of HS courses, teacher workshops, & online course
- Supplemental docs: Outlines, Notebook, Table of Contents, Image Credits
- Downloadable from: <https://www.cresis.ku.edu/education/DVD>

Spanish version will be highlighted at International Geography Conference in Santiago, Chile, in November, 2011.

Proposal submitted to NOAA to test effectiveness in 3 geographic regions with different % of Latina/o students (K-12)

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