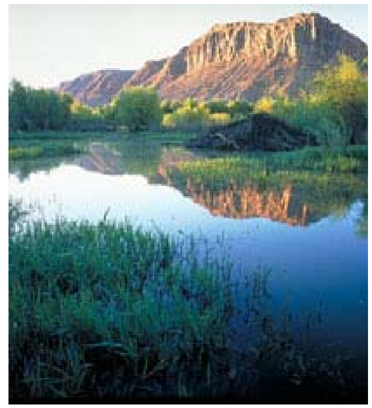
NATURAL OUTLOOKS:

CLIMATE CHANGES, ENERGY ALTERNATIVES, TECHNOLOGY OPTIONS, CONSERVATION PRACTICES, AND OUR HUMAN FUTURE



LARRY BELL

A LECTURE SERIES

Larry Bell is Professor of Architecture and Endowed Professor of Space Architecture at the University of Houston where he directs the Sasakawa International Center for Space Architecture (SICSA) and heads the Space Architecture Graduate Program in the Gerald D. Hines College of Architecture. Professor Bell and his organization's work have appeared in numerous popular magazine and media broadcast features in the US and abroad, including PBS, the History Channel and the Discovery Channel.

Larry has authored dozens of technical conference papers and professional journal articles addressing a broad variety of space and terrestrial design and technology topics, and has co-founded several successful high-tech companies. In addition to NASA Headquarters achievement and recognition certificates, he has received two of the highest honors awarded by the Federation of Astronautics and Cosmonautics of the former Soviet Union for his contributions to international space development, the Konstantin Tsiolkovsky Gold Medal and the Yuri Gagarin Diploma. His name was placed on the Russian rocket that launched the first astronaut crew to the International Space Station. He is an Associate Fellow of the American Institute of Aeronautics and Astronautics (AIAA), and a Fellow of the Explorers Club.

ABOUT THE AUTHOR

World population growth, expansion of commerce, competition for energy, environmental concerns, and dwindling fossil resources are prompting general recognition of a need to use available resources more wisely. Diverse types of organizations are working to do this. Many are exploring new operating policies, conducting technology R&D programs, putting responsive plans into action, and are demonstrating successes. Such initiatives are the right things to do, and often make good practical and economic sense as well.

Challenges of addressing ecosystem damage, climate changes, fossil fuel and freshwater depletion, and other critical issues are extremely complex and daunting. Those who seek simple solutions or reassurances that everything will resolve itself are likely to be disappointed. Yet while there are no panaceas, dire predictions about impacts of climate changes and the futility of our abilities to adopt more resourceful technologies and lifestyles are unduly pessimistic. Progress is being made on many crucial fronts.

If there is a positive side to urgent challenges facing us, it must be a growing general awareness that we are all responsible for solutions. Progress in our recognition of issues is being revealed through interdisciplinary activities involving combined and coordinated efforts of paleontologists, climatologists, physicists, space and atmospheric researchers, and others using ever-improving methods and tools. Government, university and industry programs are working across scientific and business fields to develop new technologies, products and infrastructures. Architects, developers, investors and building owners are emphasizing green design to conserve energy and reduce costs.

A “Spaceship Earth” analogy is entirely realistic. Our natural environment cannot be compartmentalized into isolated divisions defined according to cultural, economic or political priorities. Municipalities, states and nations are beginning to realize this fact, and are seeking, developing and implementing responsive policies and initiatives. It has become clear that focusing upon differences, competitive economic advantages and blame-placing will not serve long-term interests of anyone. And while cooperation often imposes difficulties that test patience, and goodwill, there is really no alternative. We are all in that tiny, fragile spacecraft together, depend upon the same life support systems, and share a vital mission.

This four-part series of lectures emphasizes how natural systems operate and connect together in intricate ways and over extreme ranges of scale and time as lessons we must recognize and apply in human endeavors.

- Recognizing that these phenomena are seamless and interdependent can reveal ways our personal and community connections to Nature and to our small planet home can be more resourceful:
  - We can more fully appreciate that human systems are not exempt from natural laws which govern survival of all life.
  - We can also become cognizant of ways that natural principles and processes can be assisted through human devices to extend resources we currently enjoy, and to preserve them for generations who follow.

Part 1, Biosystems and Climate:
Important Factors that Influence All Life on Our Planet

Part 2, Energy Resources:
Consumption, Supplies, and Important Issues

Part 3, Fuel and Power Technologies:
Outputs, Delivery Efficiencies and New Developments

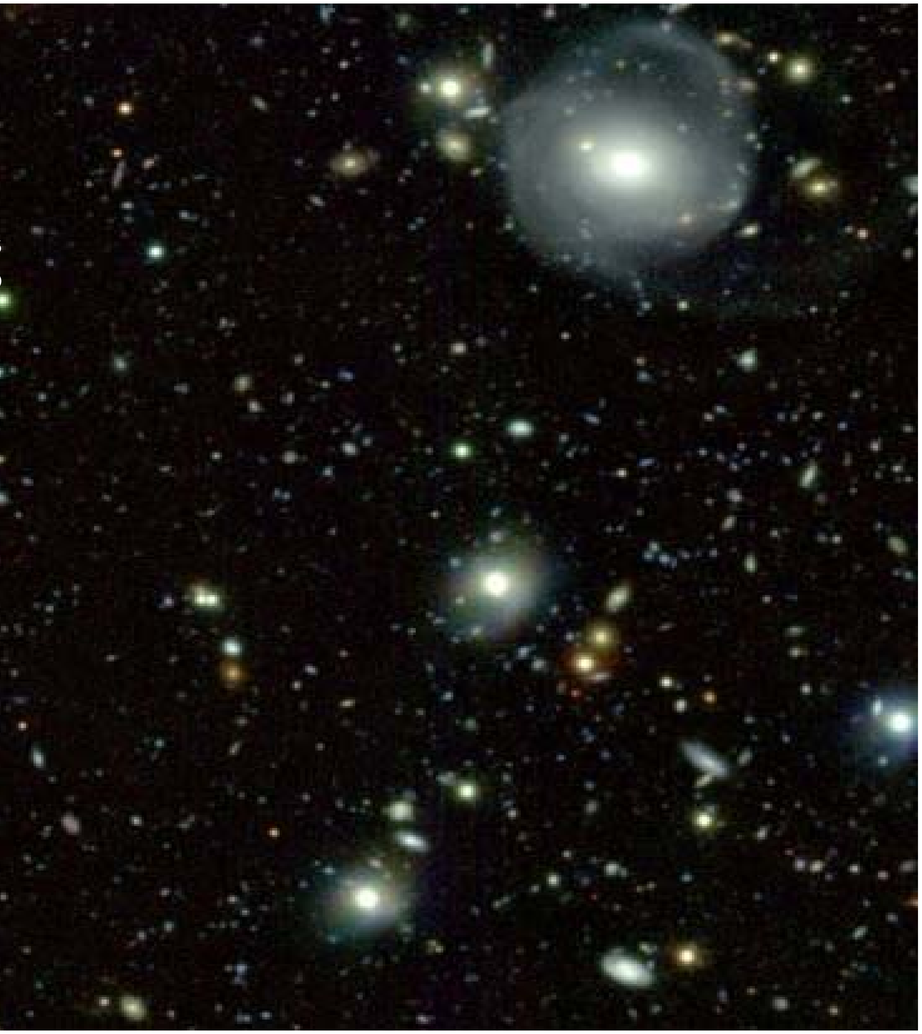
Part 4, Conservation Practices:
Water, Materials, Electrical Power and Fuel Resources.

Broad Lecture Topics

Nature's incomprehensible scale, diversity, intricacies and complex interconnections are impossible to grasp by intellect alone, leaving only spiritual consciousness to embrace its full magnitude.

From this vantage point we can perhaps be inspired by the wonders about us, rather than intimidated by a sense of insignificance and futility:

- Viewing ourselves as part of Nature's majesty can empower us to recognize that we are creatures constructed of cosmic potentials.
- We can appreciate that while we are small, everything, including Earth's Sun is tiny compared with the Universe, and that Nature makes no size distinction in assigning importance.
- Ultimately we may realize that in Nature's grand model everything is truly part of everything, including you.



Eindhoven Tech. U.
Filipe Fortes
Langfel Designs

The Cavalier Daily

Simon Ho
Trek Earth

Isreal EICI
Trek Earth
Space Daily

BIOSYSTEMS & CLIMATE:

IMPORTANT FACTORS THAT INFLUENCE ALL LIFE ON OUR PLANET

LARRY BELL

We humans are integral parts of marvelous, complex, intricate and dynamic natural "systems" that are constantly in a precarious state of balance.

- Unlike categories of fixed and bounded systems that we often define to divide Nature into more understandable parts and phenomena, true Nature is connected and synergetic.
  - It is important to realize that when we focus exclusively upon any of the parts in order to isolate and examine aspects that we are most interested in, we risk missing a much larger picture that more fully reveals Nature's true nature.
  - We should also recognize that we and our systems of living are parts of that picture, and that consequences of those systems are inseparable from the other parts which sustain us.

Wmdstar

Common use of the term “system” to identify certain interrelationships between natural objects and phenomena separate from others can sometimes imply boundaries of scale or function that obfuscates connectivity within larger frameworks.

- The way we view any system depends upon our perspective and focal range:
  - From a “big picture” perspective, we can see the Sun both as part of a much larger Cosmic System, and also as the central energy source in our Solar System powered by fusion.
  - Earth viewed from space (our Geo System) reveals weather systems on closer inspection that are driven by the Sun and Moon.
  - From close up we witness living ecosystems influenced by weather and by tiny bio-systems that provide nutrients that support them.

NASA
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Associated Content

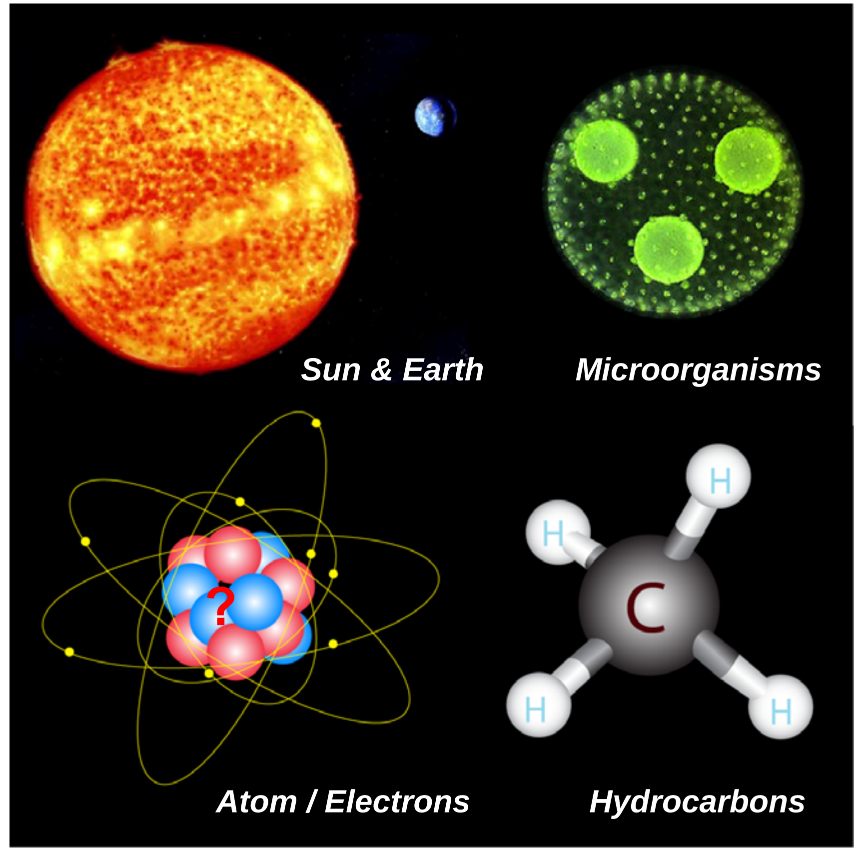
Systems of Systems

In Nature's grand model, all parts are connected and synergistic, with complex forces and processes acting in concert.

- Even the largest celestial bodies and phenomena derive their essential substance from the tiniest elements:
  - Processes that occur on the Sun drive Earth's weather and enable life to exist.
  - All plants and creatures depend upon nutrients produced by microorganisms.
  - Carbon and hydrogen constitute the building blocks of all organic life.
  - Interactions between electrons that bind atoms to form molecules create the energy fuel of all chemistry.

Spirit Alembic
J. W. Adams Comb. School

Microposy UK
Soc. For Ind.. Archeology



Systems of Systems

The Sun supports nearly all life on Earth and drives our planet's weather.

- Fusion processes convert hydrogen to helium and produce photons that travel at the speed of light, reaching Earth (a distance of about 94 million miles) in approximately 8.5 minutes:
  - Photons are mass-less, have no electric charge, and do not spontaneously decay in empty space.
  - Although some of the photons are absorbed in Earth's atmosphere, about 1,000 watts per square meter are deposited on surfaces exposed to direct sunlight.
  - Leafy plants use photons to convert CO_2 to oxygen and reduced carbon compounds that support living organisms.

NASA

The Sun is composed entirely of gas and contains more than 99.8% of the total mass in our Solar System (about 70% hydrogen and 28% helium).

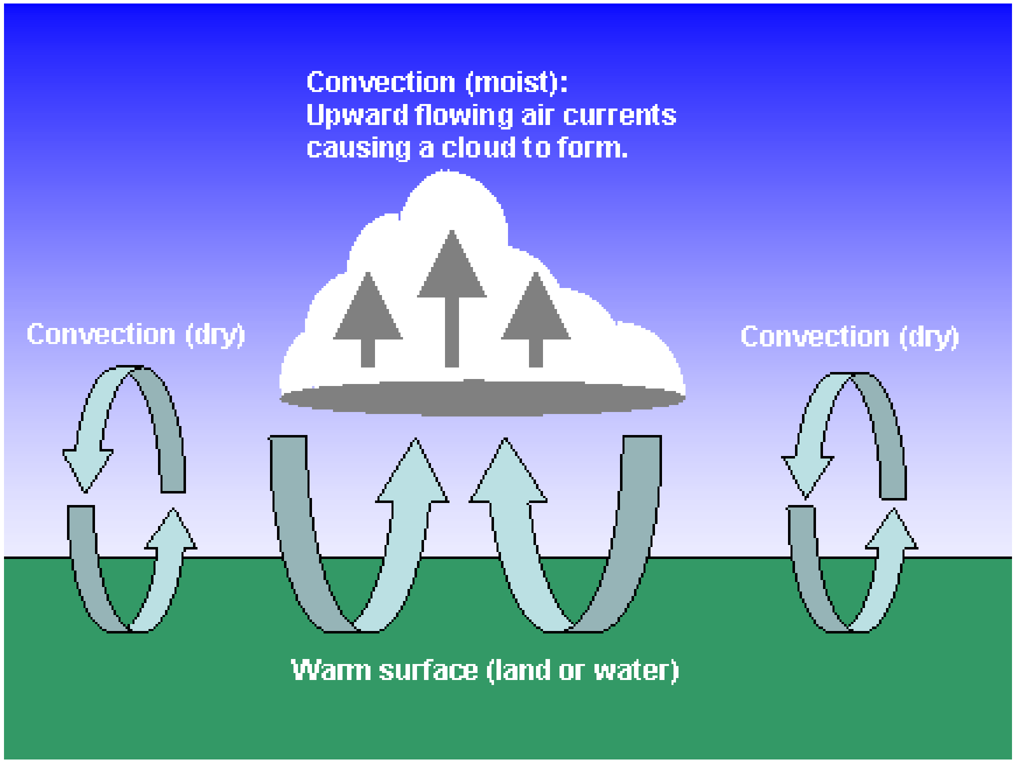
The Sun

Sun-Earth Relationships

The Sun is a primary influence on Earth's climates and weather conditions.

- Solar radiation that heats the surface and water bodies is transferred to air and circulated by convection, producing winds:
  - As heated air layers expand and become less dense, they are pushed upwards by buoyancy.
  - The rising air cools as it reaches higher altitudes in the atmosphere, becoming denser.
  - Since the denser air can't sink through the rising air beneath it, it moves laterally until it reaches the surface again and is drawn back into a rising column.

Video Weather & Weatherstreet

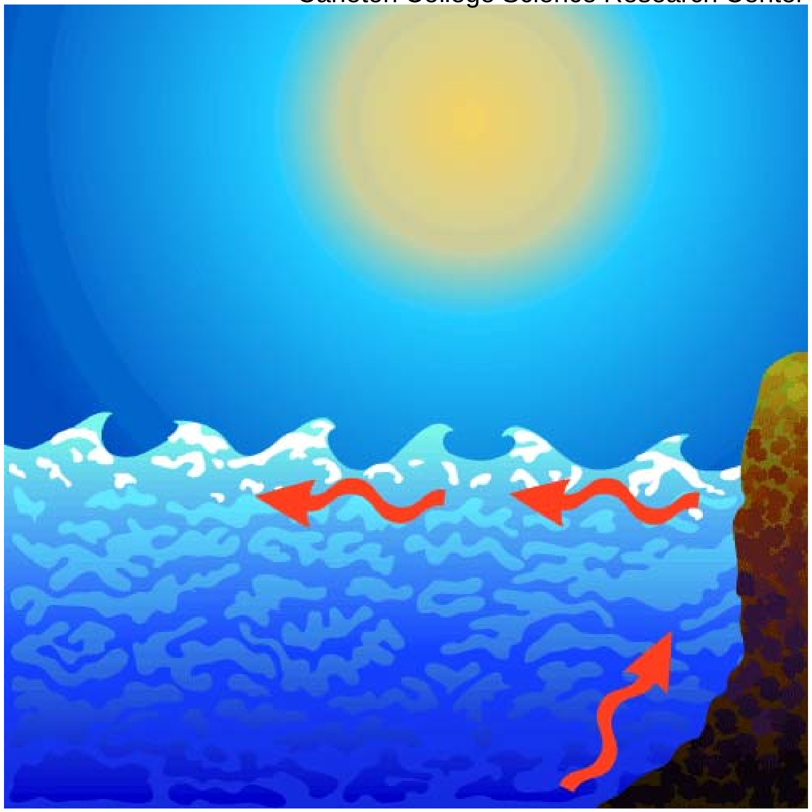


Convection currents produced by solar heat cause winds, thermals, cyclones, thunderstorms, and at a larger scale, atmospheric circulation.

Atmospheric Convection

Sun-Driven Weather

Carleton College Science Research Center



Oceanic convection driven by solar radiation and by differences in water salinity have important influences upon continental climates, particularly in coastal regions.

- Examples are the Gulf Stream which makes northwest Europe much more temperate than other regions at the same latitude, and the Hawaiian Islands, where the climate is cooler due to the California Current:
  - Equatorial water heated by solar radiation tends to circulate towards the poles, while polar water heads towards the equator.
  - "Thermoline convection" driven by differences in salinity causes relatively warm saline water to sink, while colder fresh water tends to rise and reverse heat transport.

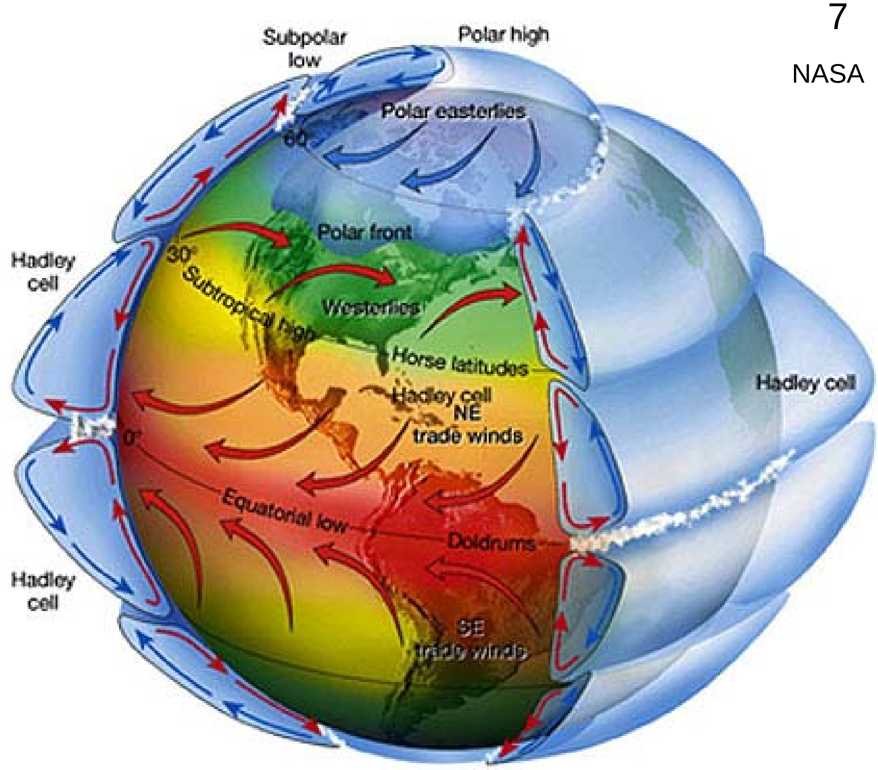
Solar heating and salinity differences produce convection effects in oceans that influence regional climates.

Solar Climate Influences

NASA

Earth's rotation also influences wind and weather.

- Winds are comprised of air molecules that are subject to Coriolis forces which cause air to turn as it flows:
  - Coriolis forces deflect wind flows to the right in the Northern Hemisphere, and to the left in the Southern Hemisphere.
  - The Coriolis deflections contribute to formations of tropical cyclones that produce extremely strong winds, tornados, torrential rain and huge waves.
  - Cyclones that often cause great human and ecological disasters also provide important mechanisms to transport heat away from the tropics and maintain equilibrium in the Earth's troposphere.
  - Hurricanes in the northeastern Pacific supply moisture to the southwestern US.



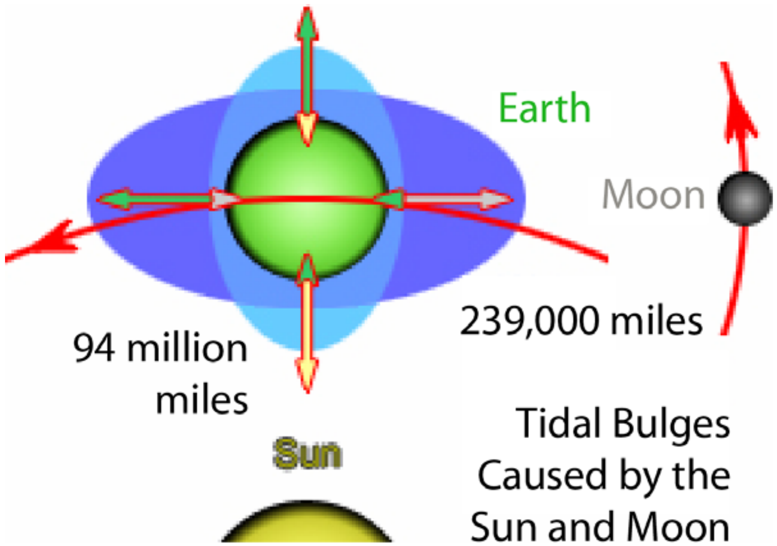
Coriolis forces produced by the Earth's rotation influence wind patterns that balance atmospheric heat, and transfer moisture to arid regions that need it.

Coriolis Influences Upon Weather

The gravitational pull of the Sun and Moon produce daily sea level changes that are essential to support marine and coastal ecological systems.

- Although these gravitational forces act upon all Earth surfaces, solid land areas remain intact, while water is lifted:
  - These forces produce two bulges in oceans, one in the direction of the Moon, and one on the opposite side of the Earth.
  - Even though the Moon's mass is 27 million times smaller than the Sun's, its closer proximity to Earth gives it a tide-generating force that is more than twice greater.
  - High tides are produced in areas where water flows between the bulges, and low tides (areas of depression) occur between bulges due to withdrawal of surging water.

Case Western University



Since distances between the Earth, Sun and Moon vary considerably throughout a year due to elliptical orbits, tide generation forces are greatest when the Earth is closest in solar orbit (perihelion), and when the Moon is closest in its Earth orbit (perigee).

Sun/Moon-Driven Tides

Tidal effects of the Sun and Moon provide critical mechanisms to support marine life and numerous types of plants and animals that reside in marshes and estuaries.

- Tidal circulation serves a variety of essential functions:
  - Tides deliver suspended sediments necessary to replace surface soils removed by runoff land erosion.
  - Flooding tides enhance plant growth by delivering oxygen-enriched water to marsh soils and removing toxic materials.
  - Tidal waters are vehicles that carry plant nutrients onto marshlands during periods of abundance, and transport excess nutrients back to estuaries at other times.
  - Exported nutrients support growth of single-celled phytoplankton that are the foundation of marine food chains.

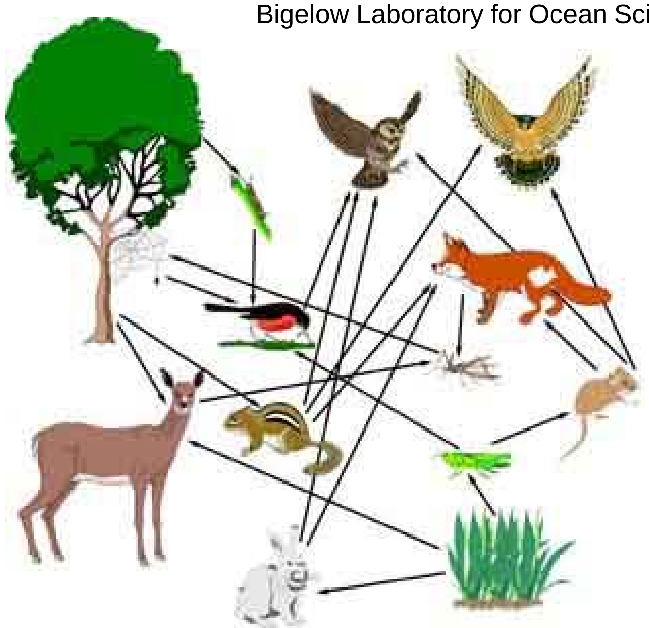
Birding America.

Tides deliver vital nutrients to coastal ecosystems and remove accumulated toxins that endanger living organisms that support food chains.

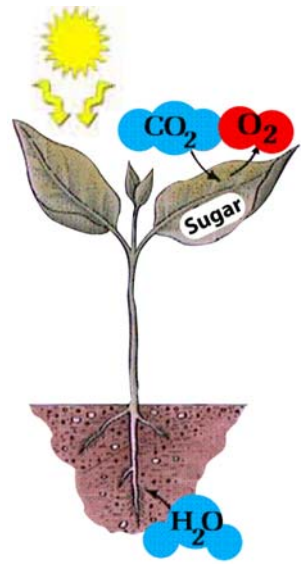
Tidal Benefits

Most ecosystems on Earth are "solar powered", depending upon food energy created by photosynthesis.

Bigelow Laboratory for Ocean Sciences



Purves, et al, *Life: the Science of Biology*



Six molecules of water taken up through roots and leaves plus six molecules of CO_2 produce one molecule of sugar plus six molecules of O_2.

($6\ H_20 + 6\ CO_2 \rightarrow C_6H_{12}O_6 + 6\ O_2$).

Photosynthesis uses sunlight to remove CO_2 (a greenhouse gas) from the air and convert it into oxygen, sugars, starches and high-energy carbohydrates that support life.

Solar-Powered Life Systems

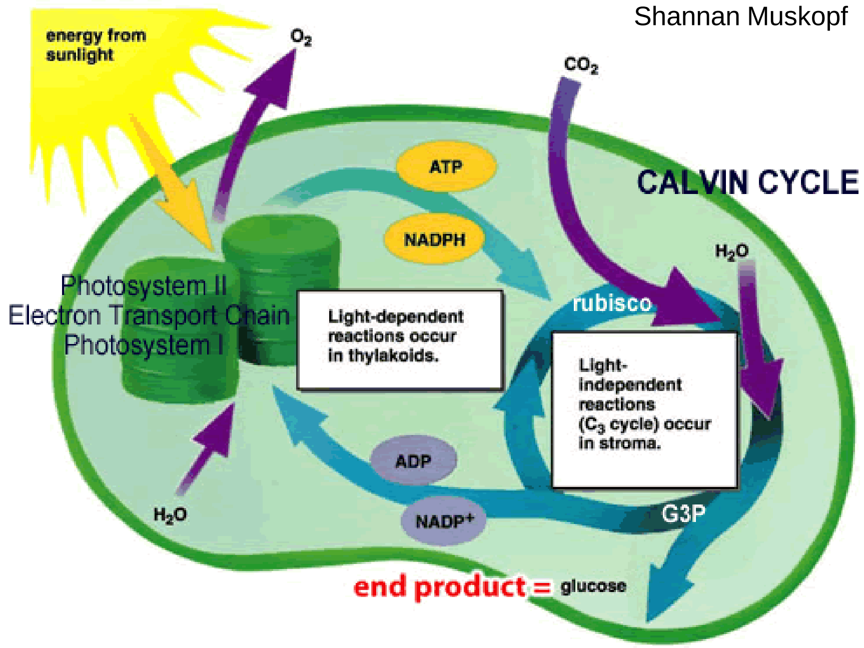
- The process occurs through two complex phases:

- In a first phase "light-dependent reaction" a pigment chlorophyll molecule absorbs light, and loses an electron in the process.

- The released electron moves down a transport chain to produce high-energy NADPH and ATP molecules, and the chlorophyll molecule regains its electron by splitting water, releasing oxygen.

- In a second phase "dark reaction" an enzyme RuBisCO captures CO_2 from the atmosphere and through a complex Calvin-Benson cycle releases 3-carbon sugars that combine to form glucose.

Shannan Muskopf

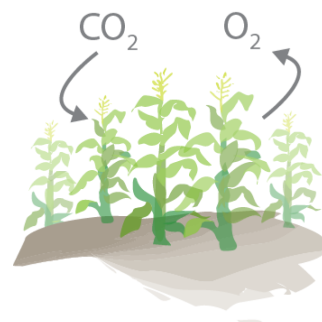


Photosynthesis Process

Solar-powered photosynthesis is arguably the most important biological process on Earth.

- Photosynthesis converts CO_2 and water into breathable oxygen to help ameliorate greenhouse gas produced by combustion, creating carbohydrates that we use for many other purposes as additional by-products:
  - One of the carbohydrates is cellulose that can be converted to sugar and fermented into ethanol (grain alcohol) for direct use as automotive fuel and as a gasoline additive to reduce pollutant emissions.
  - Ethanol can be readily converted to ethylene, an important feedstock for petrochemicals.
  - Carbon "fixed" through photosynthesis in ancient times created the biomass that is the source of fossil fuels we use today.

Larry Bell



Air Purification

Cleaner Fuels

Fossil Fuels

Petrochemicals

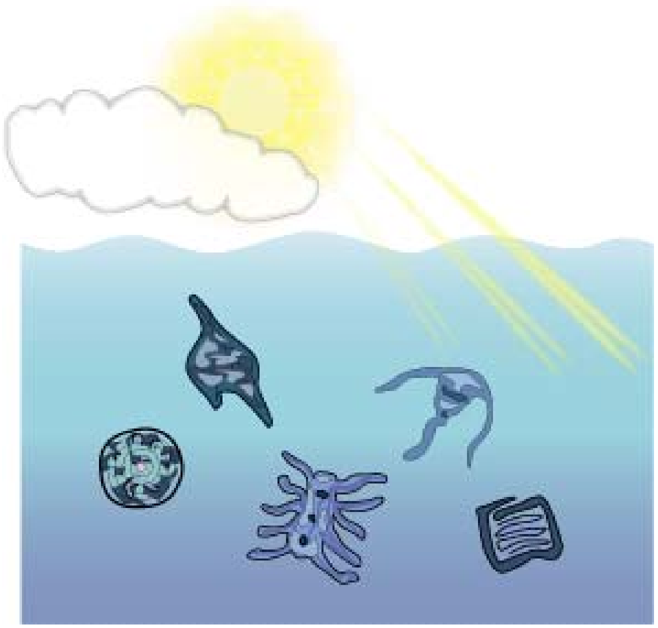
Photosynthesis Products

Solar-Powered Resources

In addition to higher plants, many types of microscopic organisms ("phototrophs") use photosynthesis to create essential food energy in marine environments.

- Despite their small size, these algae and cyanobacteria are vital to our planet's ecological survival because they provide the base of the marine food web:
  - Each level of a food chain is called a "tropic" or "feeding level" that classifies organisms as either "primary producers" or "consumers".
  - Phototrophs are primary producers because they convert inorganic materials to organic forms that "heterotrophs" depend upon.
  - Heterotrophs include carnivores, omnivores, vegetarians and decomposers.

Bigelow Laboratory for Ocean Sciences.



Solar-Powered Marine Phototrophs

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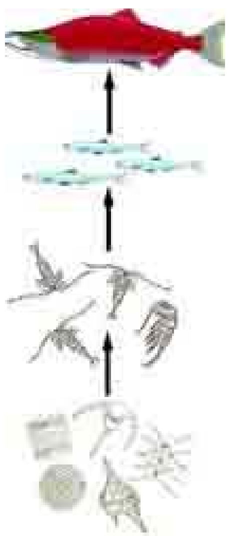
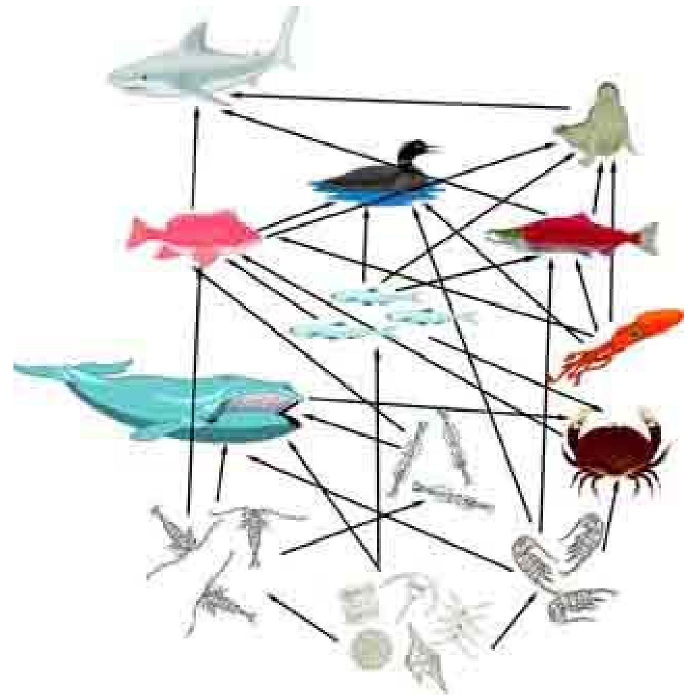


Organism	Trophic Type	Prey/Food
algae	primary producer	---
birds	carnivorous consumer	krill, fish
blue whales	planktivorous consumer	algae, krill
fish	omnivorous consumer	algae, krill
killer whales	top consumer	blue whales, fish, birds, seals
krill	herbivorous consumer	algae
seals	carnivorous consumer	fish, birds

Marine Food Chains

Bigelow Laboratory for Ocean Sciences

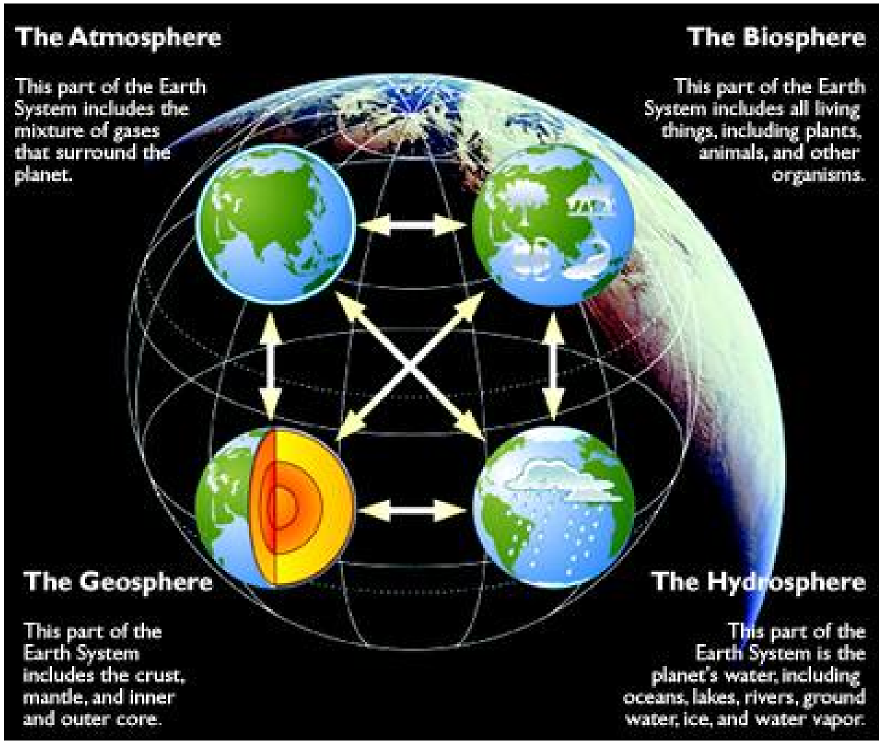


Marine Food Webs

The Earth is often characterized as being comprised of four general types of connected zones or “spheres”.

- The atmosphere provides a protective gaseous blanket:
  - It contains oxygen, nitrogen and carbon dioxide essential for life, and provides weather.
- The geosphere consists of Earth’s solid material and inner core:
  - It contains minerals and compounds that comprise organic and inorganic materials.
- The biosphere contains all living systems:
  - About 97% is contained in oceans.
  - This includes organisms ranging from viruses to humans that exist in the geosphere and hydrosphere.
- The hydrosphere (part of the biosphere and atmosphere):
  - This includes all of Earth’s water and water vapor.

It’s About Time



The Earth Viewed as Systems

Viewed as systems within a larger system, the spheres of influence interact in dynamic and complex ways to maintain the equilibrium necessary to sustain life.

- The atmosphere serves as a large global transport system:
  - It circulates oxygen, water, nitrogen, carbon dioxide and heat among regions.
- The geosphere affords a foundation for life:
  - It provides inorganic substances to support organic chemistry, geothermal heat, and a CO_2 containment service.
- The hydrosphere supports marine life and land creatures that depend upon it:
  - It also influences weather, provides water for precipitation and cooling, and absorbs CO_2 from the atmosphere.
- The biosphere exchanges life support products and biowastes with other spheres:
  - It is the source of biomass fuels and nutrients, and converts CO_2 into O_2 and back again.

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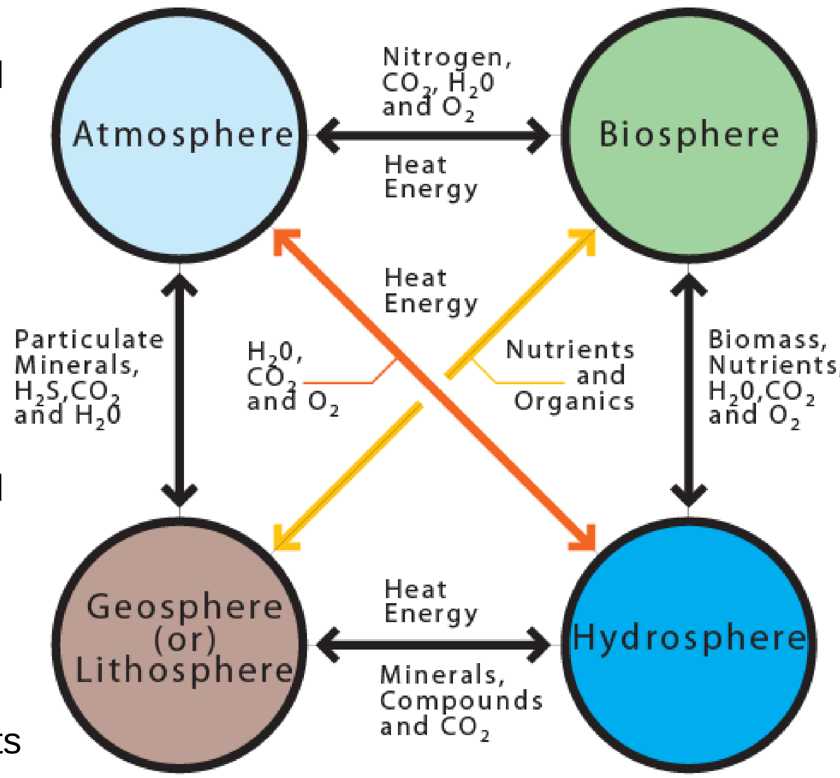

Connections and Synergies

The atmosphere is also characterized as being comprised of different zones, or “spheres”.

- The thermosphere is the uppermost region where solar radiation strips off (ionizes) electrons from atoms in the ionosphere below. (Temperatures increase with altitude here because the atoms don’t absorb solar radiation).
- The ionosphere is a layer that traps radio signals and allows them to travel around the world (unless disturbed by solar storms that disrupt communications).
- The mesosphere has no strong solar radiation absorbers, causing temperatures to decrease with altitude.
- The stratosphere is broken into different materials (stratified), including ozone which absorbs solar radiation so that temperatures increase with altitude.
- The troposphere (lowest level) is where convection occurs to produce weather, and temperatures increase with altitude.

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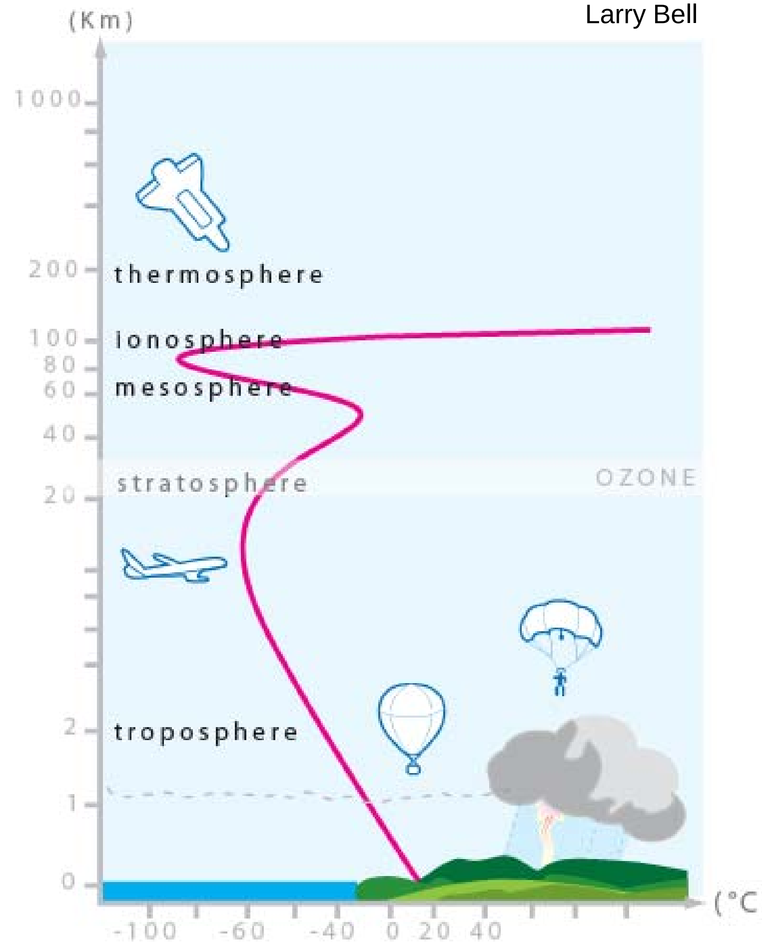
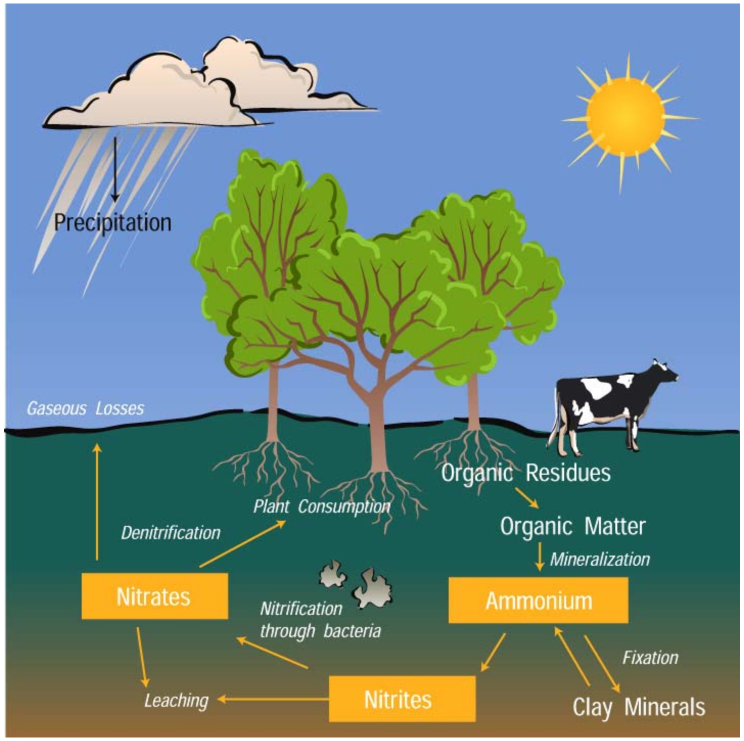


Atmospheric Zones

Nitrogen comprises about 78% of the atmosphere and cycles slowly through the biosphere.

- Although very little nitrogen is present on land or in the oceans, it is essential to life as a key element in proteins and DNA:
  - Nitrogen does not chemically react very readily with other substances because each molecule is made of two atoms that are tightly bound together.
  - Large amounts of energy are required to break the atomic bonds, although this can occur through lightning and fires.
  - Fortunately, an assortment of bacterial species specialize in converting nitrogen from the air into usable forms, and also release nitrogen from organic material back into the atmosphere.

Windows to the Universe, UCAR



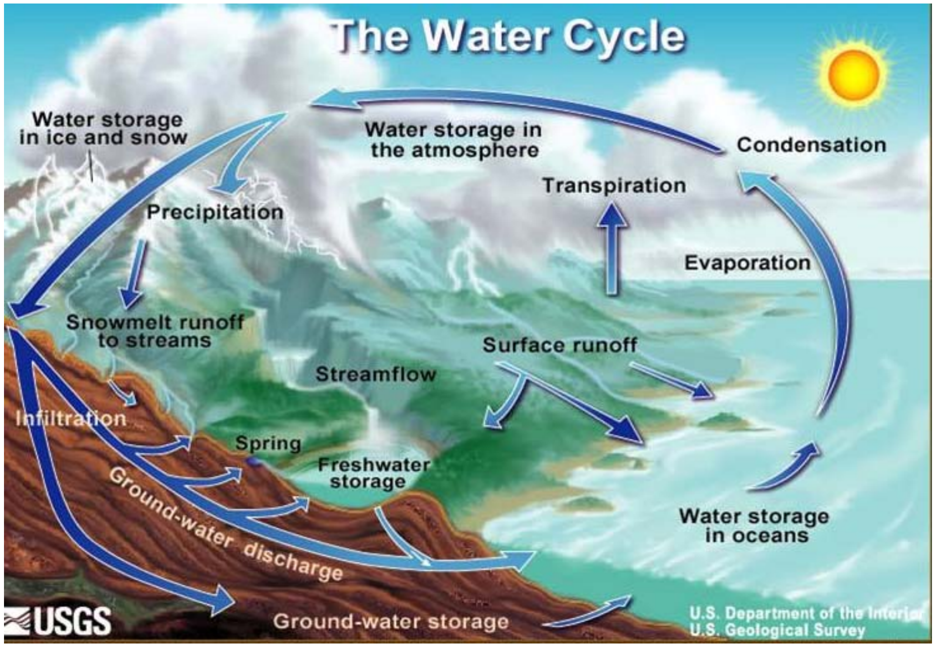
The Nitrogen Cycle

Water in liquid and vapor form cycles continuously through the geosphere, hydrosphere, atmosphere and biosphere.

- Water molecules comprise the primary substance of all higher plants and animals:

- It is transferred between the hydrosphere and biosphere by evaporation and precipitation, releasing heat energy in the process.
- In the air, water vapor circulates and condenses to form clouds, and rain that falls back to the surface.
- Plants and animals use and reuse water, and release the vapor back into the air.
- Some water leaches into underground aquifers, releasing suspended particles in the filtering process.

US Geological Survey



The Water Cycle

Oxygen comprises about 21% of the atmosphere.

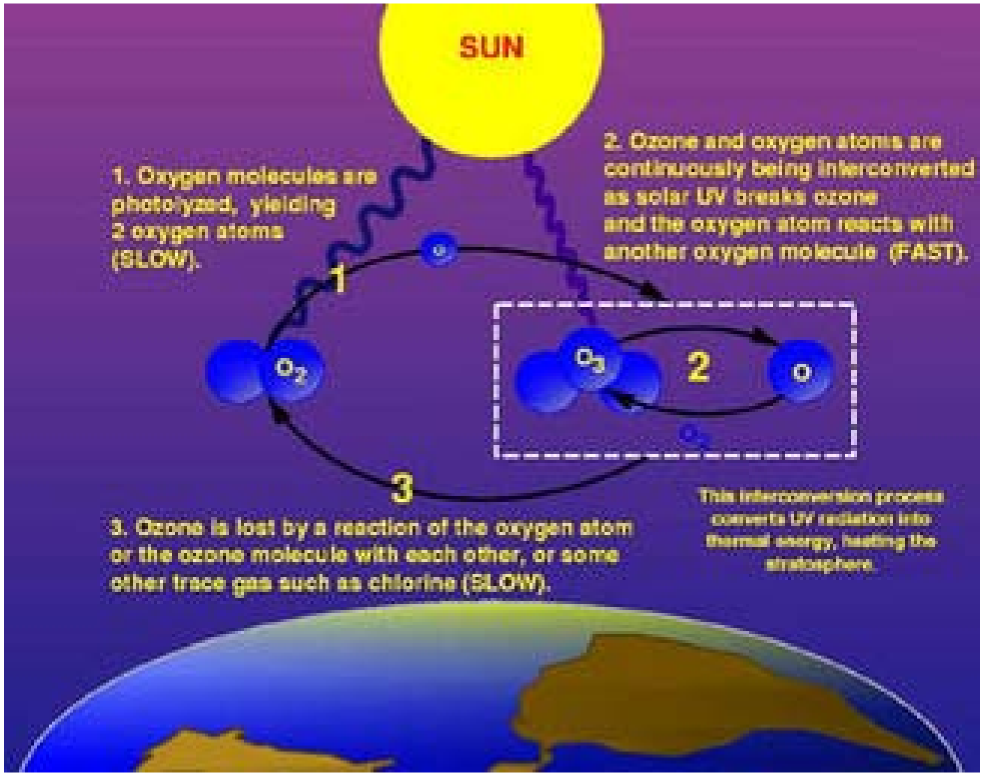
- Although oxygen is very reactive and rapidly combines with other elements and “disappears”, relatively stable concentrations are replaced through photosynthesis and plant respiration:

- Some oxygen is lofted into upper reaches of the atmosphere (the stratosphere) where a series of reactions powered by solar radiation convert it into ozone (O_3).

- The ozone beneficially serves to absorb biologically-damaging ultraviolet (UV) radiation, reducing the amount that reaches the Earth’s surface to a tiny fraction.

- Ozone molecules eventually break apart to reform into O_2, which circulates again through the atmosphere to repeat the cycle.

Google Answers



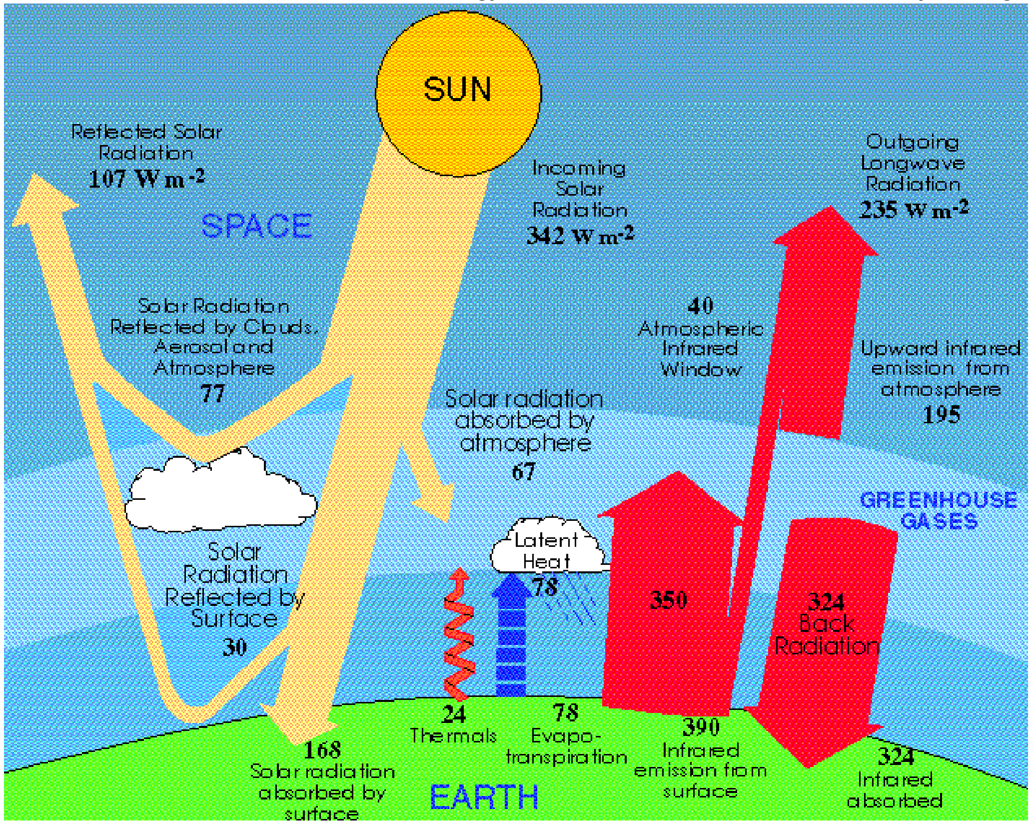
Radiation-powered reactions in the stratosphere continuously convert oxygen molecules to ozone, which eventually reforms back to oxygen.

Oxygen-Ozone Cycles

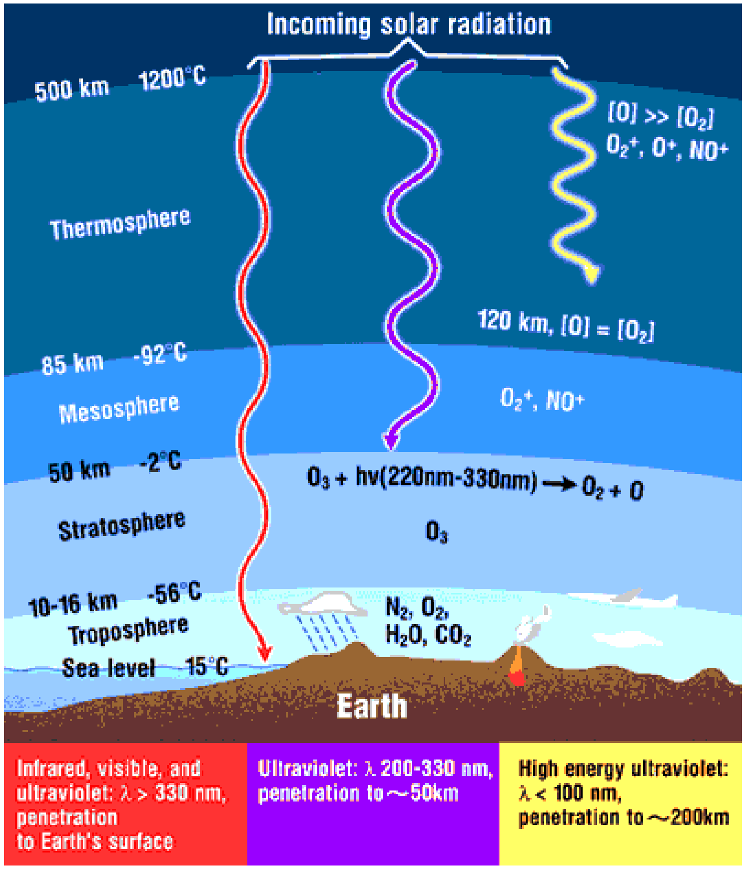
The Earth's thermal balance is in a steady state when the energy stored in the atmosphere and oceans equals the incident solar radiation radiated back to space.

- This radiation includes reflected solar radiation and emitted thermal infrared radiation (IR):
  - The Earth receives about 30% of the incident solar radiation flux, and the remaining 70% is absorbed, warms the land, atmosphere and oceans and powers life on the planet.
  - Eventually the absorbed incident energy is radiated to space as IR photons.
  - This thermal (IR) radiation increases with rising temperatures.

Online Biology Book. Estrella Mountain Community College



Steady State Thermal Balance



Atmosphere Transparency vs. Altitude and Incoming Radiation Wavelengths

The amount of thermal radiation released to space is influenced by the atmospheric opacity and temperature.

- These factors determine the height from which most photons are emitted to escape:
  - If the atmosphere is more opaque, an escaping photon must go higher in order to “see out” to space in IR.
  - Since IR emission is influenced by temperature of the atmosphere, the temperature will influence the emission level required to balance the absorbed solar flux.
  - The temperature of the atmosphere generally decreases with height above the surface at the rate of about 15.7°F per mile (6.5°C per kilometer) up to the stratosphere (6.2 miles - 9.3 miles [10km - 15km altitude.])

Since the atmosphere emits IR both upwards and downwards, the temperature balance between energy radiated to space must be equal to the direct incident radiation absorbed plus the downward IR flux.

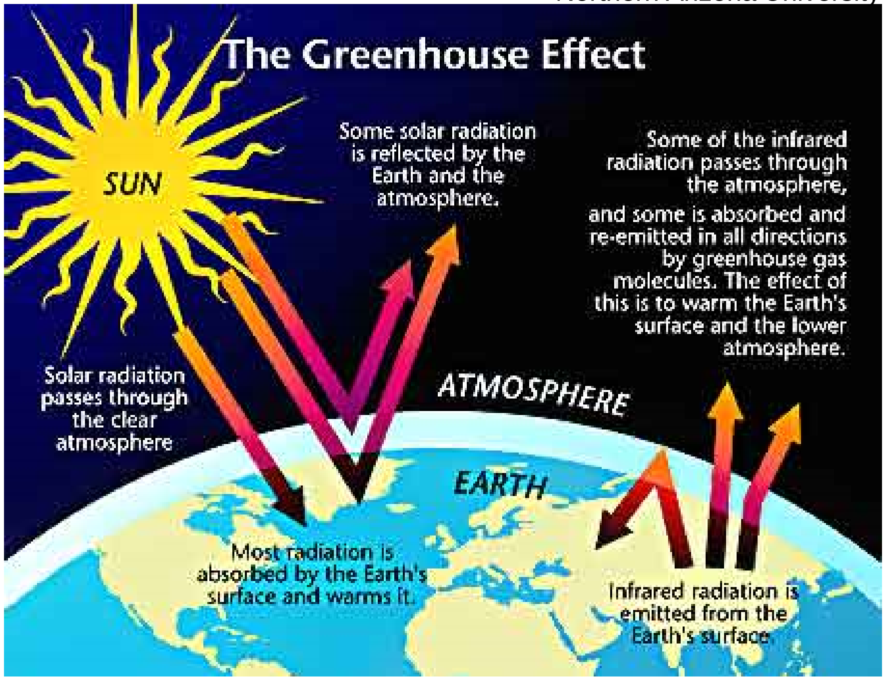
- The atmosphere is relatively transparent to the direct incident radiation in the visible range, but strongly absorbs thermal IR wavelengths emitted by the surface and atmosphere:

- Most IR escaping to space is emitted from the upper atmosphere (not the surface).

- Accordingly, most IR photons emitted by the surface are absorbed by the atmosphere and do not escape.

- A large part of the thermal energy transfer to the atmosphere occurs through convection (sensible heat transport) and evaporative condensation of water vapor (latent heat transfer).

Northern Arizona University



The "Greenhouse Effect"

Increases in greenhouse gases, CO_2 in particular, reduce the amount of IR energy emitted to space, causing surface temperatures to rise over time.

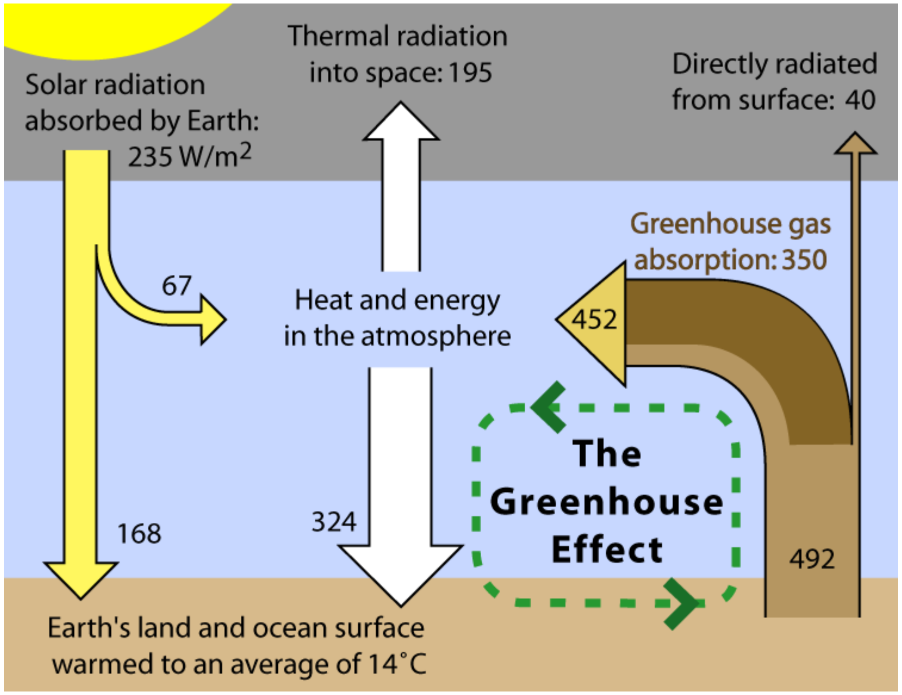
- Dominant infrared-absorbing gases in Earth's atmosphere are water vapor, carbon dioxide and ozone:

- Clouds are very important IR absorbers, and become more prominent through evaporation as surface water temperatures increase.

- CO_2 is a linear molecule which becomes "floppy" and easily excited by IR so that it bends with carbon in the middle, moving one way, and oxygen on the ends moving the other to vibrate and absorb IR energy.

- It is estimated that water vapor may contribute about 36% of the total absorbing effect, and CO_2 somewhere between 4% - 12%.

Global Warming Art.

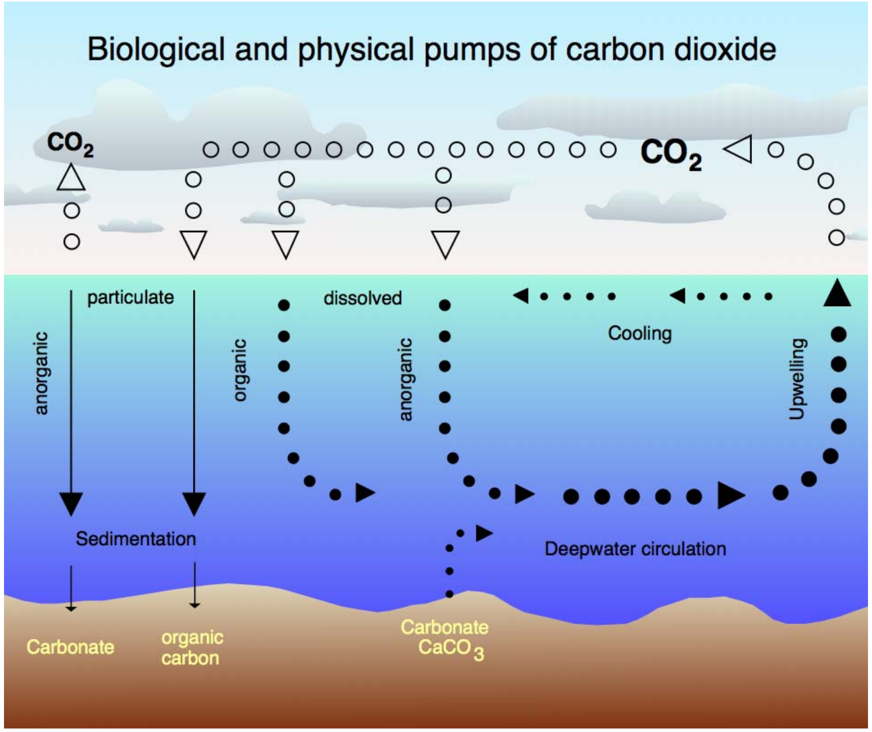


Greenhouse Mechanisms

Atmospheric CO_2 derives from many natural sources, including volcanoes, ocean sediments, combustion of organic matter and fossil fuels, respiration of living aerobic organisms, and cellular respiration of microorganisms.

- Records from polar ice cores and ocean sediments indicate that atmospheric CO_2 concentrations have naturally fluctuated greatly throughout the Earth's history, reaching levels higher than those observed in recent decades:
  - Volcanic activity was essential to create a warm, stable climate essential for life when the Earth was young, but now releases only about 1% of the amount produced by human activities.
  - Levels rise and fall on a seasonal basis as a result of plant growth cycles, warming and cooling changes that influence ocean absorption rates and other factors.
  - The US National Oceanographic and Atmospheric Administration estimates that about 97% of annual atmospheric CO_2 comes from natural sources, and about 3% from human activities.

Hanues Grobe, et al. Inst.for Polar and Marine Research



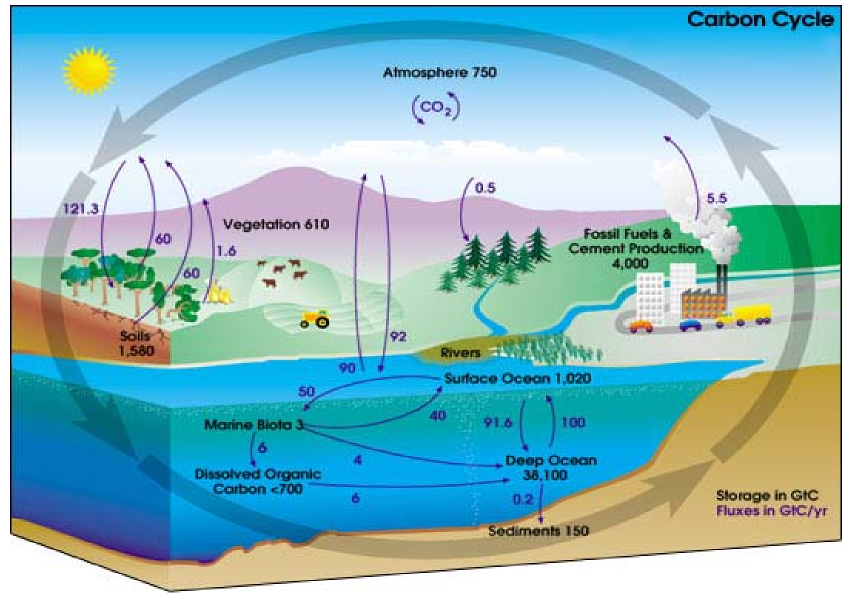
CO_2 from Ocean Carbonate

Carbon, typically in the form of CO_2, cycles between “reservoirs” provided by the atmosphere, biosphere, hydrosphere and geosphere.

• Natural reservoirs can function either as CO_2 sources or sinks:

- Atmospheric carbon is primarily CO_2 (overall only about 0.04% on a molecular basis), although other gases containing carbon are present in even smaller amounts (e.g. methane and artificial chlorofluroro-carbons [CFCs]).
- CO_2 is dissolved at ocean surfaces, particularly in polar regions where the water is cold.
- Aerobic respiration by plants and animals breaks down glucose into CO_2 and water, and photosynthesis reverses the process.
- Limestone, marble and chalk mainly comprised of calcium carbonate are eroded by ocean water to produce CO_2 and carbonic acid.

NASA



CO_2 is constantly being released into the atmosphere and hydrosphere from hydraulic erosion of limestone deposits, biomass decomposition, fossil fuel combustion and other sources.

Atmospheric CO_2 Sources

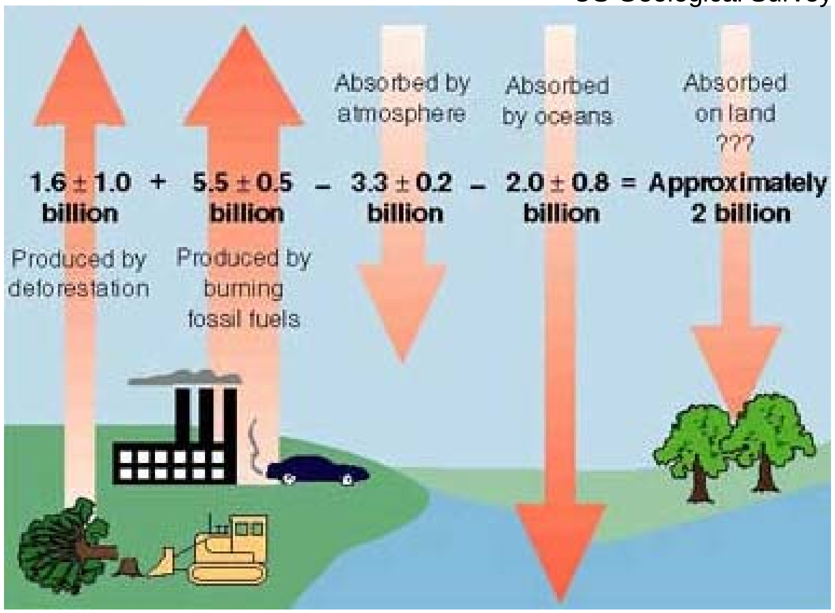
While it is evident that atmospheric CO_2 levels have increased about 110 ppm from a pre-Industrial Revolution level of 280 ppm to about 360-380 ppm now, the actual influences of this trend upon global warming or its future consequences are not nearly as clear.

- Although CO_2 represents only a very tiny amount of total atmospheric gas content (less than 4/100ths of 1% which is much lower than water vapor per volume and weight), steady increases over the past 50 years are raising international concerns:

- Much or most of this increase is generally attributed to human causes, yet computer models cannot yet reliably predict climate change impacts.

- Key areas of uncertainty include heating and cooling influences of clouds upon the atmosphere, roles played by oceans, and land influences such as deforestation, agriculture, and seasonal changes.

US Geological Survey

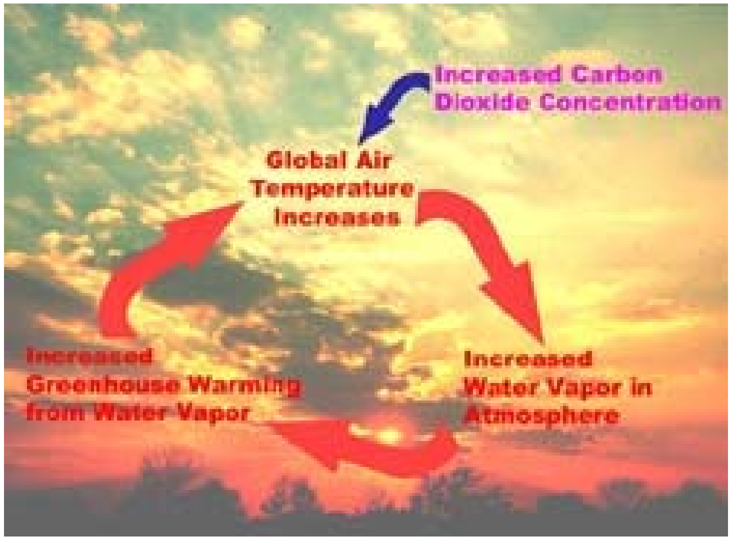


Estimated Human Contributions

Atmospheric CO_2 is produced by a variety of human and natural sources, with much ultimately absorbed by the atmosphere, oceans, and vegetation. Many researchers believe that influences upon Earth temperature changes may be well within natural climate variability.

Atmospheric CO_2 Influences

NASA



Water vapor in combination with CO_2 and other greenhouse gases have feedback influences that compound warming effects.

- Since the concentration of a greenhouse gas in the atmosphere is a function of temperature, a feedback produced by another greenhouse gas can increase the temperature, to in turn increase the concentration of the original gas.

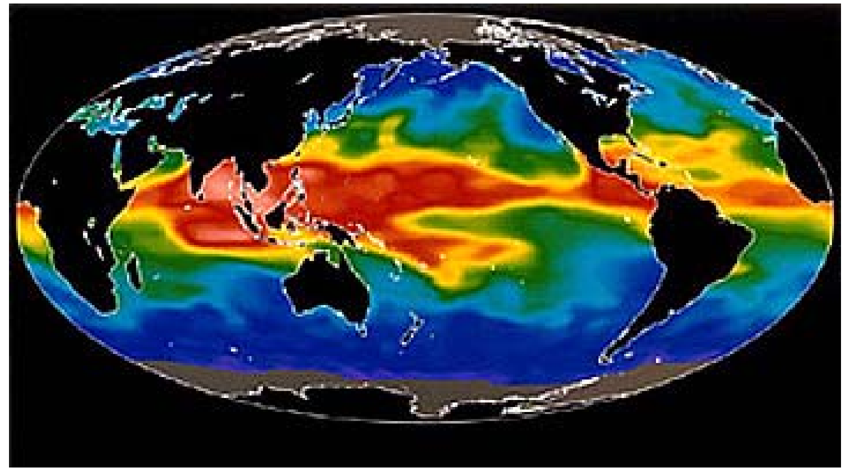
- Water vapor is known to experience a “positive” feedback in response to increases in CO_2 concentrations

- While most of the atmospheric CO_2 is released from natural sources, even relatively small increases resulting from human activities may have substantial impacts.

Water vapor in the atmosphere is known to act as a greenhouse gas that contributes to Earth warming. As surface temperatures rise, more water from oceans evaporates, adding to atmospheric vapor levels (A “positive water feedback”). Research based upon data from NASA’s Upper Atmosphere Research Satellite (UARS) has confirmed this effect, but suggests that the impacts may not be as large as previous climate change models have assumed.

Water Vapor as a Greenhouse Gas

NASA Goddard



Satellite Water Vapor Imaging

Although water vapor is a primary greenhouse gas, upper atmosphere satellite measurements at a 6-9 mile (9.5-14 km) altitude show less positive feedback correlation between vapor concentration and Earth warming than previous computer models predicted.

Separate satellite measurements of global surface and ocean precipitation between 1979-2004 also reveal virtually no net vapor concentration increases due to climate warming evaporation effects.

Water Vapor Influences

Climate "forcing" factors include a variety of combined natural and human influences that impact Earth's atmospheric chemistry and surface heat balance.

- Although much attention has been directed to biogeochemical effects of CO_2, some other factors have comparable and even greater effects:

- Atmospheric water vapor may account for about 70% of all greenhouse effect (compared with somewhere between 4.2%-8.4% for CO_2), absorbing solar infrared over much of the same wavelength bands as CO_2, and even more.

- While clouds are comprised mostly of water droplets (not greenhouse gases) they absorb about one-fifth of the long-wave radiation from Earth, although their influences upon climate mechanisms are not fully understood.

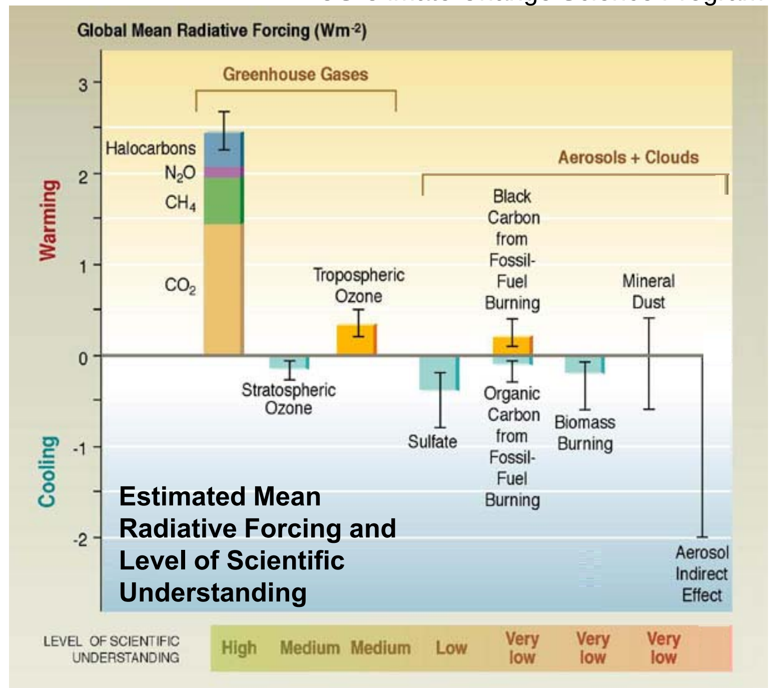
Aerosols include atmospheric dust particles and sulfate droplets released from natural sources such as volcanoes, sea spray and land wind erosion in combination with human activities such as fossil burning from industry and forest clearing for agriculture.

- Current models for distinguishing concentrations from natural vs. human sources, or assessing climate effects, are unreliable and often contradictory due to issue and calculation complexities:

- It is generally believed that unlike greenhouse gases, sulfate aerosols tend to cause cooling rather than heating by scattering radiation at the top of the atmosphere. This enhances reflectivity that reduces cloud lifetimes by increasing the number of droplet collisions needed to produce rain.

- Dust particles do this to some extent, but also absorb some sunlight to produce warming effects.

US Climate Change Science Program



Aerosols tend to create cooling rather than warming effects. They remain in the atmosphere for only days or weeks before they fall out or are washed out by rain. These short periods do not allow enough time for mixing to occur that would enable global transport associated with greenhouse gases.

Estimated Aerosol / Greenhouse Influences

Human influences upon land uses and vegetation can also have a variety of complex links to weather and climate mechanisms, including surface-atmosphere greenhouse gas exchanges, reflected and absorbed radiation and thermal balances, and wind interactions with surface topologies.

- Growth of agriculture has had particularly significant land use influences over much of the world:

- Although global impacts are not well understood, replacement of dark forests with croplands is known to affect local conditions, increasing surface albedo levels to cool some regions, while denying shade to other heavily-irradiated areas to raise ground temperatures.

- Large-scale crop irrigation can also produce measurable regional cooling effects, as has been demonstrated in the Great Plains of North America since 1945.

UCAR
Exec. Action Team

U. of Missouri
Julian Pye

Human land use influences upon weather and climate are associated with a number of factors, including growth of farming and industry, population size and distribution, and types of technologies used in each region. The combined effects of these impacts can, in turn, affect the suitability of the land and land cover for desired future uses.

Land Use Influences

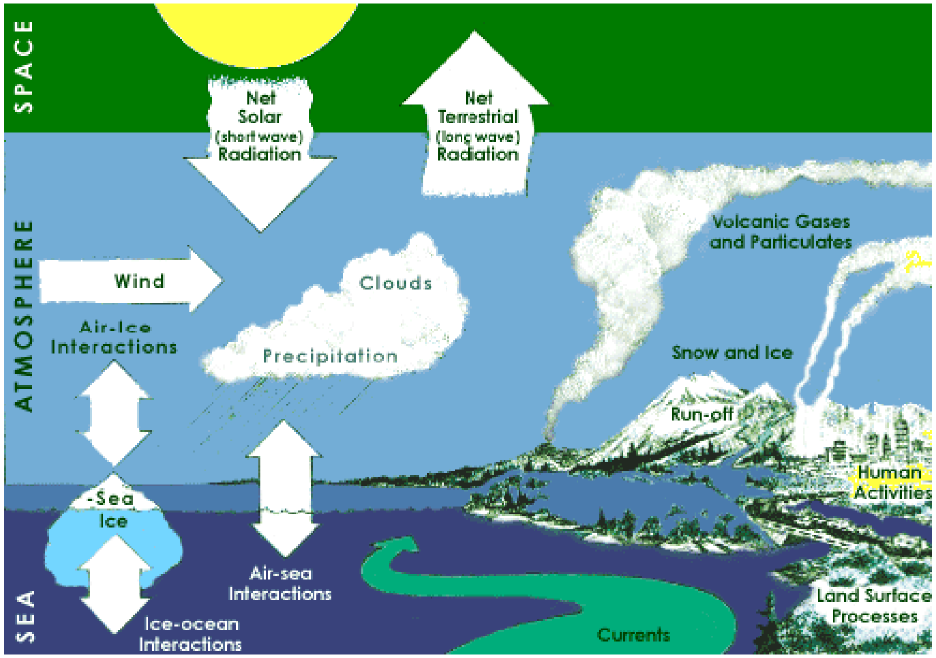
Simple theories about causes and consequences of climate change fail to recognize that these phenomena involve a complex interplay of overlapping cycles and events that sometimes cancel each other out.

- Extreme modeling difficulties and fluctuations that occur naturally often cast legitimate doubts about trend predictions based upon a few years or decades of limited data and incomplete understanding of interrelationships:

- Urgent concerns about human impacts upon these influences and outcomes are certainly legitimate and essential, both as a moral obligation to our planet and as a practical matter of survival.

- The challenge is to avoid premature, faulty conclusions and policies driven by inadequate models, unsubstantiated hypotheses, and alarmist observations based upon both.

Solcomhouse



Climate and temperature changes are influenced by many highly interactive forcing factors that are not well understood as a basis for developing accurate or reliable models.

Climate and Temperature Influences

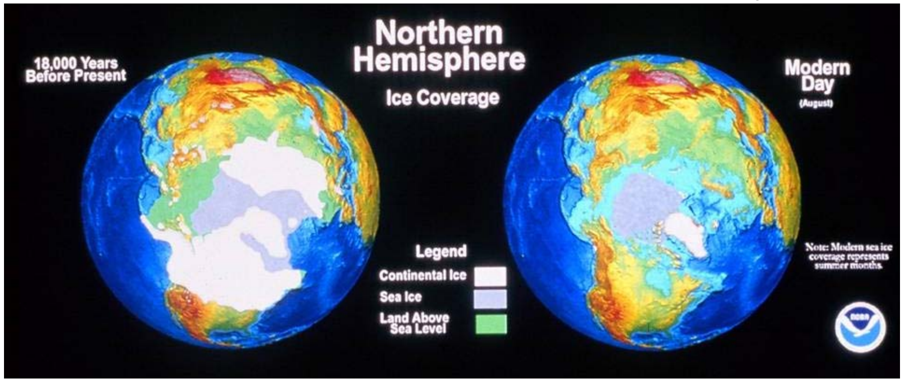
Important issues and controversies concerning human impacts upon climate revolve around questions regarding which observed trends and fluctuations are natural or "normal".

- In regard to global temperatures it can be argued that normal can be characterized by ice ages that have dominated Earth's history:

- Except during brief interglacial periods, our planet's climate has been invariably glacial, with more than half of the surface covered with ice and arid deserts.

- Present global warming trends began about 18,000 years ago near the end of the Pleistocene Ice Age when much of North America, Europe and Asia began to thaw out from a very long deep freeze.

Australian Academy of Science



Earth has been relatively ice-free even at high latitudes, only during relatively short interglacial periods such as our current one. From a historic perspective our climate is, without doubt, "abnormally warm".

Past and Present Northern Hemisphere Ice Coverage

The average temperature of the Earth has been gradually increasing on a fairly constant basis over the past 18,000 years or so following the last 100,000 year-long Ice Age when much of North America lie buried under glaciers:

- By about 12,000 – 15,000 years ago the Earth had warmed sufficiently to halt the advance of glaciers and cause sea levels to rise.
- About 8,000 years ago a land bridge across the Bering Strait became submerged, cutting off the migration of people and animals to North America, ultimately rising about 300 feet.
- Since the last Ice Age Earth's temperature has risen about 16°F, and plant life returned to regions previously covered by ice.
- Temperatures may have continued to rise about 1 degree over the past 200 years, although the precise amount is debated according to measurement methods used.

Wm. Robert Johnston

Earth has been relatively ice-free, even at high latitudes, only during relatively short interglacial periods such as our current one. From a historic perspective, our climate is without doubt "abnormally warm".

The Last Ice Age, About 16,000 BC

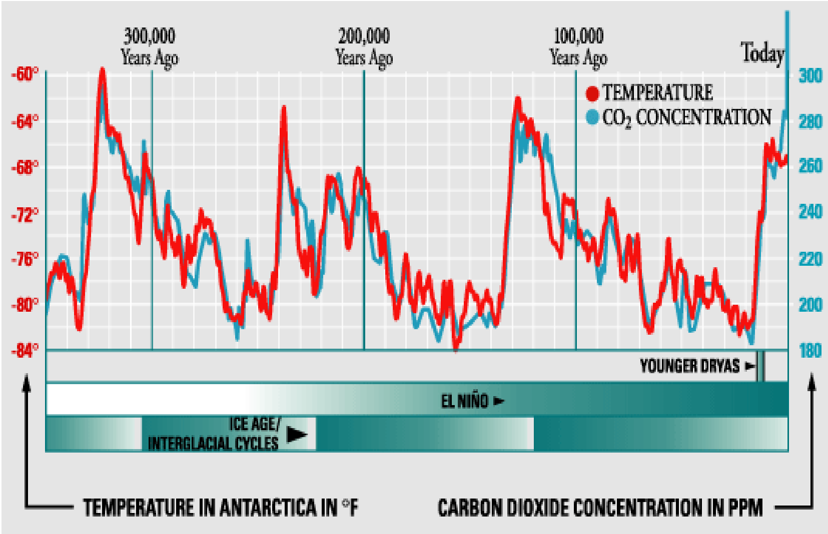
No one can really predict how long our current interglacial period will last before the next glacial period arrives, and if the term "ice age" is used to refer to a long generally cool interval when glaciers advance and retreat, some can argue that we are still in one today.

- Although a "typical" interglacial may be estimated to last about 12,000 years, this is difficult to substantiate from ice core records, and our current one may be more analogous to a previous interglacial estimated to exist for 28,000 years:

- The Earth has seen at least four major ice ages, with many glaciation cycles of advancing and retreating ice sheets within and between them.

- These warming and cooling periods seem to occur in small-scale cycles of about 40 years, within larger-scale 400 year cycles such as the Little Ice Age, within still larger 20,000 year cycles, and so on.

Maria Koshland Museum of the National Academy of Sciences



Over more than the past 400,000 years of Earth's history, ice ages have occurred at regular intervals of about 100,000 years each. These cycles have witness changes when huge glaciers have destroyed entire regional ecosystems and altered topographical surface features.

Glacial and Interglacial Cycles

Except for relatively brief interglacial episodes such as the "Eemian" that peaked about 125,000 years ago and our present one, much of the Earth's surface has been under a siege of ice over most of the past 160,000 years.

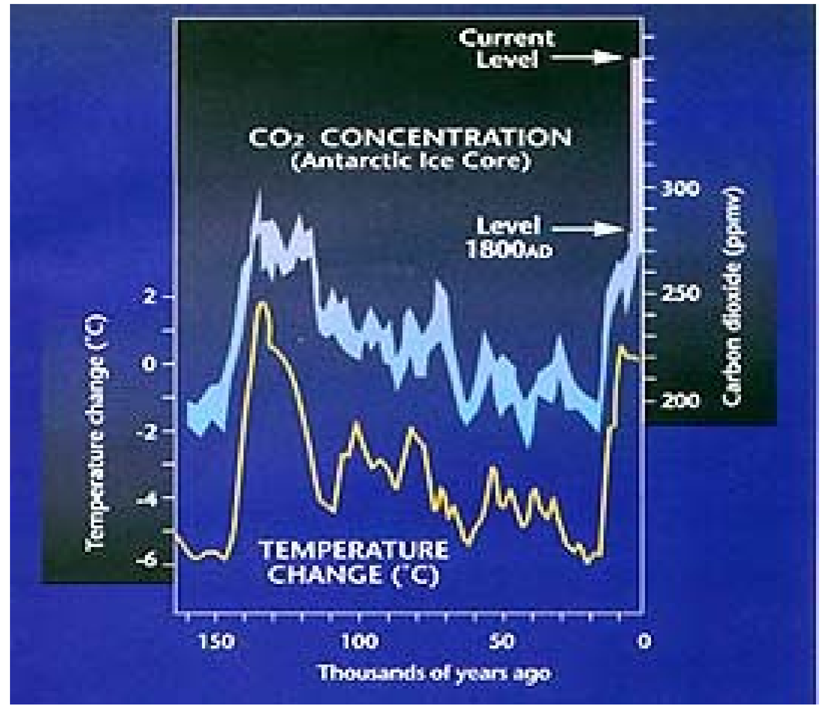
- Occurrences and impacts of these and other glacial periods has been verified by three types of methods:

- Geological studies reveal evidence in the form of rock scouring and scratching, glacial moraines, valley cutting and other surface effects.

- Chemical analysis of isotope variations in sedimentary rocks, ocean sediment and ice cores reveal biological changes and extinctions.

- Paleontological surveys of fossil distributions indicate when and where cold-adapted organisms spread into higher latitudes, and others requiring warmer conditions became extinct or migrated into lower latitudes.

NASA Goddard



Early Climate Changes (Past 150,000 Years)

Interglacial periods, such as ours, appear to be characterized by great climate variability.

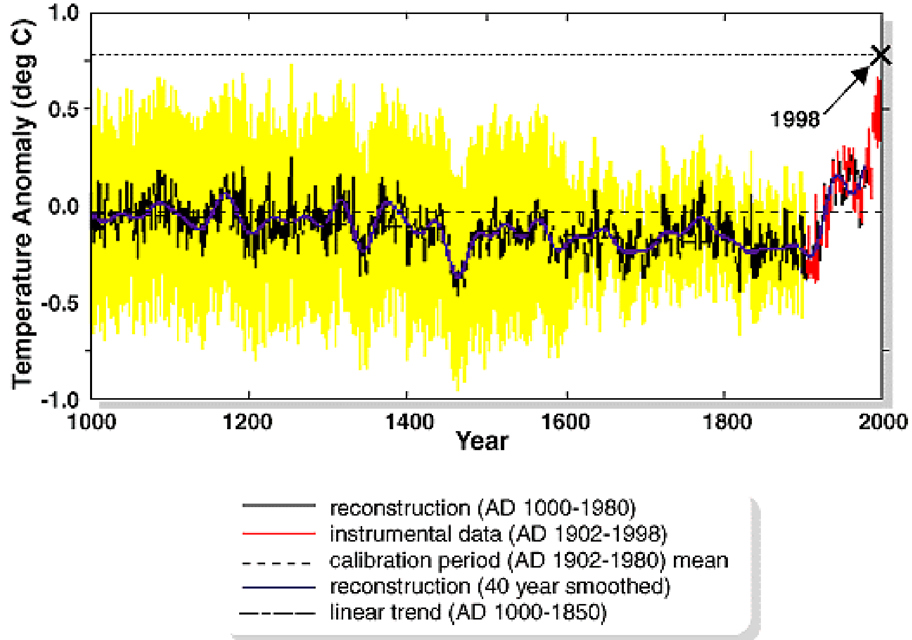
- Contemporary observations reveal constant fluctuations from month-to-month, season-to-season, year-to-year, decade-to-decade, and century-to-century:

- The 19th century ended the well-documented, centuries-long Little Ice Age that brought "abnormally cold" temperatures to many parts of the world, and may have biased observations commencing during the second half of that century as "normal", and the 20th century as "abnormally warm".

- Today's climate is generally comparable to that of the Medieval Warm Period (believed to extend from the 9th-13th centuries AD) which preceded the Little Ice Age.

- Dramatic, but very temporary changes were also witnessed as influences of tropical Pacific conditions that produced warming during El Niño in 1997-98, followed by cooling during La Niña.

NOAA Climate Data Center



The Northern Hemisphere has experienced significant climate shifts during the past 2,000 years, ranging from the Medieval Warm Period, the Little Ice Age which followed, and the warm period we are currently experiencing.

Northern Hemisphere Climate Shifts

Ironically, much research suggests that the Northern Hemisphere of our planet is ultimately heading towards a protracted new glacial age.

- During the past million years Earth has experienced a major ice age about every 100,000 years, interrupted briefly by warmer "interglacial" periods like our current Recent Holocene that last about 12,000 years or so:

- About 21,000 years ago, North America and northern Europe were covered by ice sheets estimated to be about 1.9 miles (3km) thick.
- More recently, about 6,000 years ago, a thaw caused ice sheets to retreat to Greenland and Antarctica and stream into the sea.
- Although the last thousand years have been generally mild, substantial fluctuations have occurred, such as the "Little Ice Age" which brought bitterly cold weather to many parts of the world during the 17th and 18th centuries.

Hendrick Avercamp

Scene inspired by the harsh winter of 1608 in The Netherlands during the Little Ice Age

Rather than continued global warming, our planet may quite likely be near the end of a relatively short period between major ice ages. Periods such as these are characterized by abrupt, vacillating, and sometimes extreme climate changes, ranging from cold to hot, and wet to dry. An example during this present interglacial occurred in the Northern Hemisphere between the 16th and 19th centuries.

Little Ice Age Cooling Paradox

If Earth climate patterns hold true to recorded schedules, a predicted ice age may present even more serious adaptation challenges than global warming, creating both food and energy shortages.

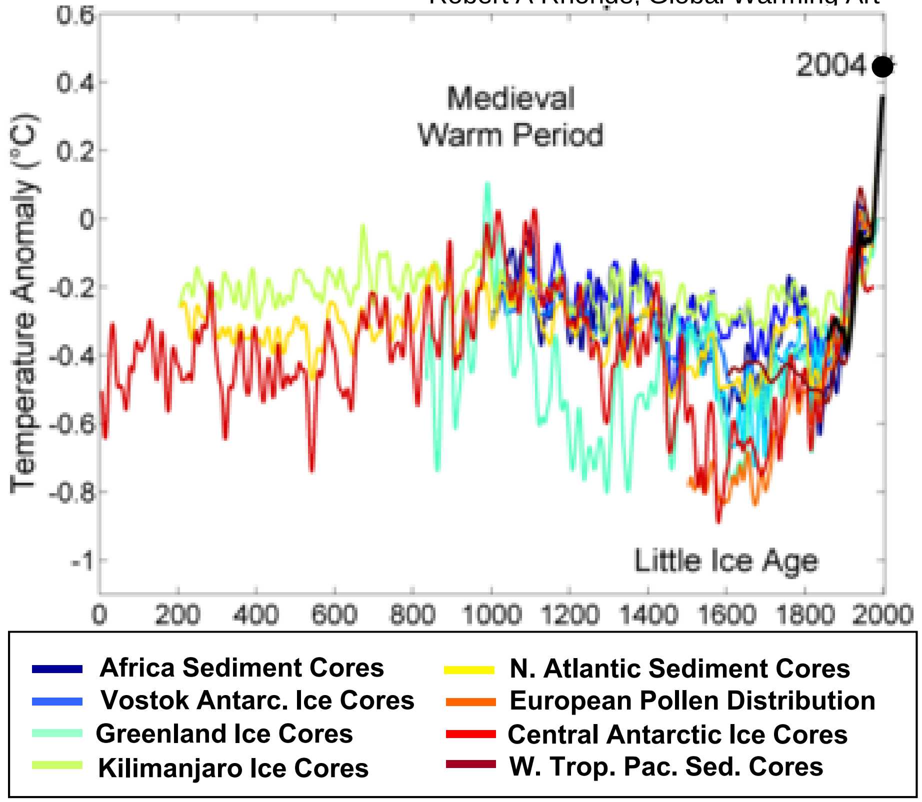
- Results of the Little Ice Age (not a real glacial ice age) can offer some examples of such consequences:

- In 1250, Atlantic pack ice began to grow; warm summers stopped being dependable in Northern Europe in 1300; torrential rains followed, and the Great Famine of 1315-1317 required crop practices to be altered in order to adapt to shortened, unreliable growing seasons.

- Later, in the mid-17th century, glaciers in the Swiss Alps advanced to gradually engulf farms and villages; the Thames River and canals of The Netherlands froze over (as did New York Harbor by 1780); and sea ice closed shipping harbors in Iceland.

- The climate began to warm again beginning in about 1850 to more recent conditions.

Robert A Rhonde, Global Warming Art



Estimates of temperature changes differ based upon various studies and methodologies used.

Earth Climate Changes (Past 2,000 Years)

Analyses of ocean sediment cores drilled off the African coast indicate that climate shifts may have dramatically influenced the course of human evolution.

- These recent studies reveal occurrences of three major climate cycles that coincide with developments evident in fossil records:

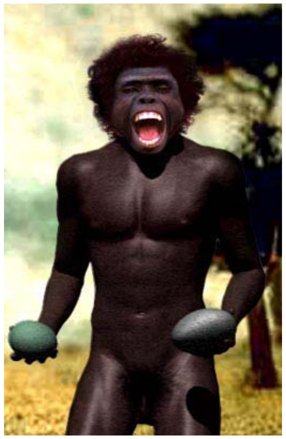
- Brief, oscillating warm/wet and cold/dry climate cycles about 2.8 million years ago became progressively colder and longer, killing off fruit trees, rainforests and species that depended upon them, while grassland species thrived.

- After that period Australopithecus Afarensis (known as "Lucy") evolved and divided into at least two separate lineages, the genus Paranthropus and genus Homo, and the first stone tools appeared.

Content Answers

Lucy
About 2.8 Million Years Ago

Archaeology Info



Homo Erectus
About 1.7 Million Years Ago

Michigan State U.

Homo Sapien
About 130,000 Years Ago

Another period of colder, drier African cycles about 1.7 million years ago caused Homo Habilus to die out, and a larger-brained Homo Erectus first appeared along with more sophisticated tools used by our human ancestors.

About 1 million years ago when cold, dry periods again became extreme, the genus Paranthropus became extinct, and Homo Erectus migrated from Africa to eventually evolve into modern humans, the Homo Sapiens.

Influences on Human Evolution

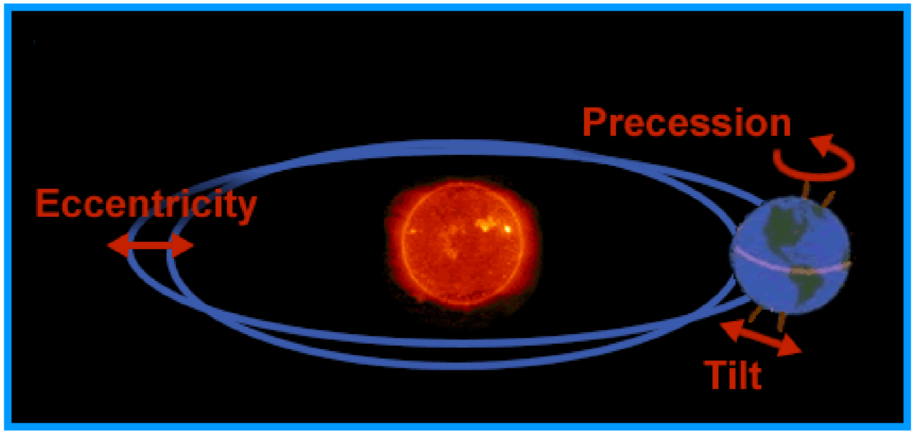
Although causes of major glacial events are not confidently understood, changes in Earth's orbit are often considered to be important factors.

- Variations in the shape (or eccentricity) of Earth's orbit around the Sun (called "Milankovitch" cycles) and in the planet's tilt axis both affect the amount of sunlight received on the surface, influencing periods of warming and cooling:

- Tilt is usually considered to be the most important of these in terms of glacial and interglacial periods.

- Distance changes as Earth processes elliptically around the Sun are expected to have contributing effects, particularly with regard to climate shifts within an interglacial period.

University Corporation for Atmospheric Research



Changes in the Earth's orbit eccentricity and its axis tilt angle can produce changes over thousands of years. Its axis is offset from the perpendicular by an angle that "wobbles" from a minimum of 22.5° to a maximum of 24° over about a 40,000-year cycle. It is currently tilted at 23.5°. Approximate 100,000-year dominant patterns of glacial periods roughly correspond with both types of changes.

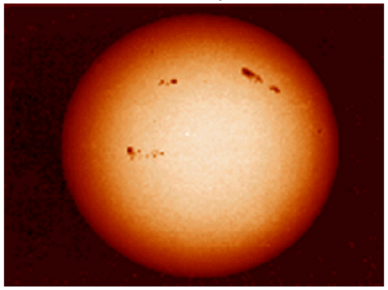
Influences of Earth's Orbit

Other naturally-occurring conditions are also theoretically linked to major climate changes.

- Key among these are variations in solar outputs, tectonic plate movements and events that alter Earth's atmosphere:

- Changes inside the Sun over time affect energy that reaches the Earth's surface, causing either warming or cooling. (NASA research indicates that this may have been a factor during the Little Ice Age.)
- Migrations of Earth's tectonic plates over long time scales may have influences. (Ice ages seem often to begin when continents are in positions that obstruct warm water flow from the equator to the poles, causing ice sheets to form.)
- Volcanoes and oceans release greenhouse gases that can produce warming effects, and large meteorite strikes release dust that block sunlight (a cause cited for dinosaur extinctions).

NASA
Isaac Newton Group

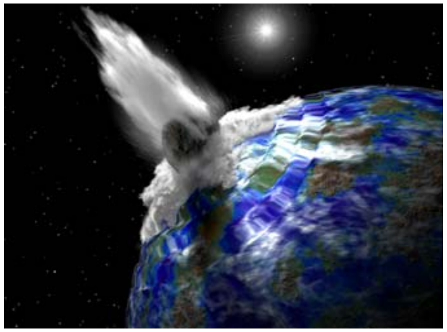


The Sun's output is estimated to increase about 10% each billion years, and sunspots produce short-term effects.

NASA
Orbit @ Home

A continent at the top of a pole (as Antarctica is presently) can block warm water flow.

Volcanoes produce dust and aerosols that block sunlight, and also release warming greenhouse gases.



Dust ejected by large meteor strikes may have blocked sunlight and cooled some regional environments in the past.

Other Potential Influences

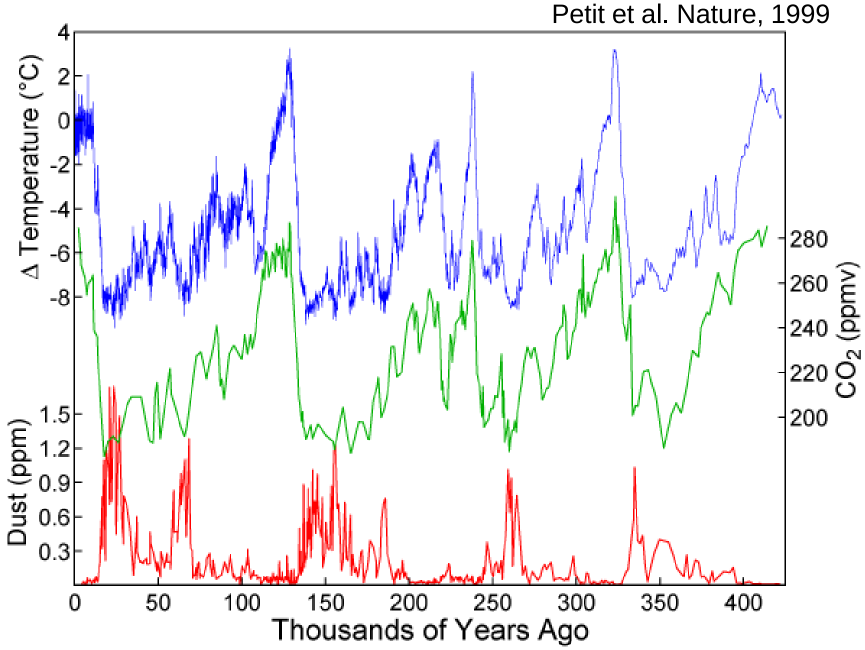
Geological evidence shows that over the past 400,000 years CO_2 levels and temperatures have greatly fluctuated at regular intervals, with temperature rises preceding CO_2 increases.

- CO_2 levels today are similar to the Eemian interglacial period that occurred between 120,000-140,000 years ago which was followed by a full-fledged ice age immediately afterwards:

- Atmospheric CO_2 has been rising steadily since about 18,000 years ago when Earth began to warm its way out of the Pleistocene ice age that covered much of North America, Europe and Asia with glaciers.

- Records indicate that CO_2 levels fall at the start of ice ages when more of the gas is absorbed by the colder oceans, and levels rise during glacial retreats when the processes reverse.

Petit et al. Nature, 1999



Core samples taken from Vostok ice show direct correlations between CO_2, temperatures, and dust over the last 400,000 years. Warmer global temperatures release higher CO_2 levels from oceans, events that may be triggered by Earth's orbit changes and/or other causes.

Correlations with Atmospheric Dust and CO_2 Levels

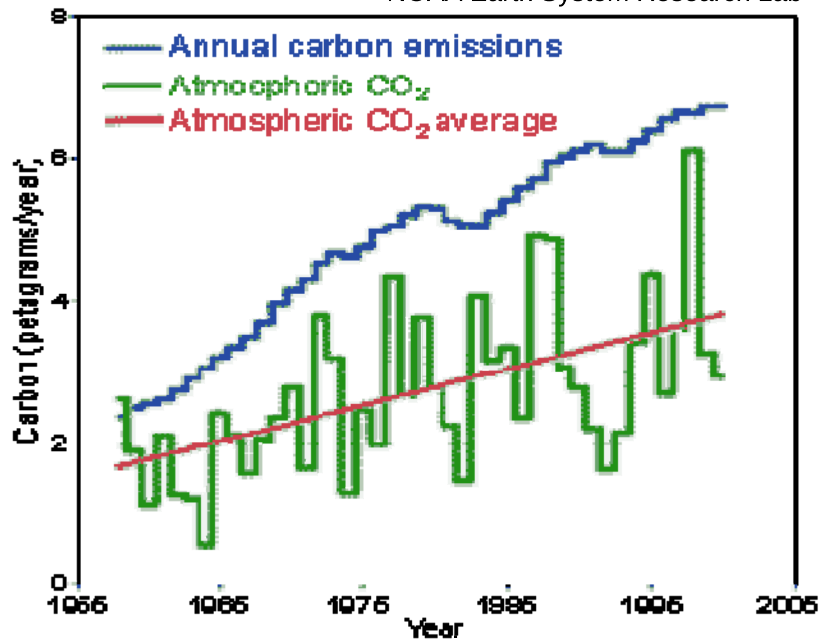
Influences of atmospheric CO_2 concentrations upon climate change and human-induced enhancements in particular, are issues of continued uncertainty and controversy.

- Although CO_2 levels have generally been observed to increase during warm periods and fall with colder temperatures, it is not clear which condition causes the other:

- Atmospheric CO_2 measurements at remote Northern Hemisphere sites have shown nearly linear increases of about 1.4 ppm / year since 1972, a rate seemingly unaffected by a large 45% increase in fossil fuel combustion emissions between 1972 (4.4Gt) and 1995 (6.4Gt).

- Previous climate shifts between the Medieval Warm Period and Little Ice Age also raise questions, having occurred long before the Industrial Revolution or invention of the internal combustion engine.

NOAA Earth System Research Lab



On average, only about half of CO_2 emissions released by fossil fuel combustion remain in the atmosphere, with inter-annual fluctuations due to variations in natural sources and sinks.

Global CO_2 Fossil Combustion Emissions vs. Atmospheric Concentrations (billions of tons of carbon / year)

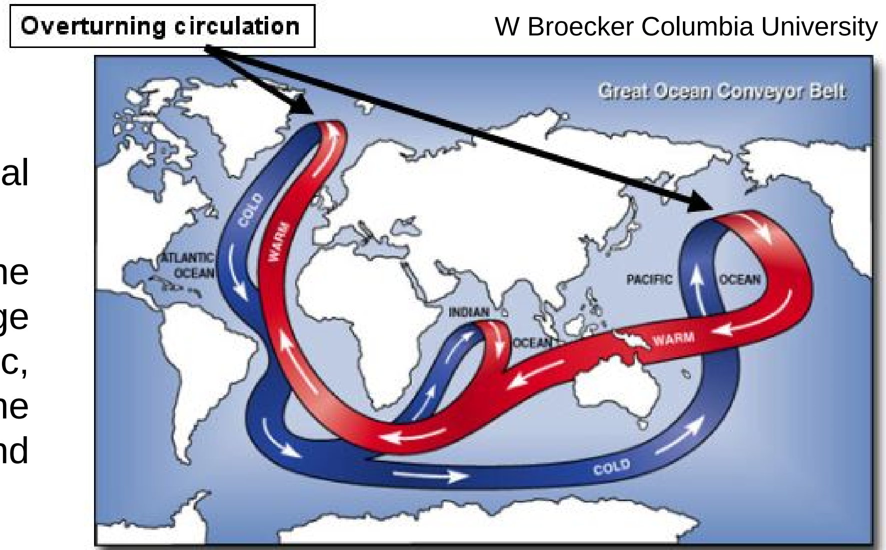
At least one theory suggests that global warming may actually trigger a mini-ice age.

- This possibility is supported by the appearance over the past 30 years of huge freshwater "rivers" in the salty North Atlantic, along with a recent drop of salinity in the Labrador Sea between Canada and Greenland adjoining the Atlantic:

- It is suspected that these events may have been caused by melting Arctic ice that might subvert northern movement of heat-laden tropical Gulf Stream waters.

- Instead of transferring heat to eastward winds that warm Europe in winter and then sinking as it cools and becomes denser, the North Atlantic fills with fresh water that is less dense and doesn't sink, remaining on top of the ocean like a big thermal blanket

W Broecker Columbia University



Thermoline Circulation in the North Atlantic

Terrence Joyce who chairs the Woods Hole Physical Oceanographic Department in Cape Code, Massachusetts believes that freshwater infiltration into the North Atlantic from melting Arctic ice could shut down thermoline circulation that powers heat transfer from the tropics to Europe in winter. Such a shutdown might possibly precipitate a sudden drop in North Atlantic water temperatures and bring colder temperatures to land masses on both sides of the ocean.

Possible Mini-Ice Age Warming Trigger

Broad alarm during the mid-1980s about indications of global cooling portending the arrival of a new ice age reversed to predictions of cataclysmic warming threats by the later part of that century.

- The existence, magnitude and causes of this potential threat are subjects of contentious scientific and public policy debate:

- Measurements taken after about 1940 did seem to indicate a cooling trend, although declines slowed to halt in the late 1970s.
- Observations since the 1980s have recorded slow but steady increases in global near-surface temperatures in combination with rising amounts of atmospheric CO_2.
- Atmospheric balloon and satellite instrument measurements since 1979 have seemed to indicate smaller temperature increases than ground stations, although differences appear relatively minor and uncertain.

Larry Bell

Ground Station Measurement Critics	Balloon/Satellite Measurement Critics
If monitoring stations are located in urban areas, they may become heat islands that skew results upward.	Measurements show a lack of observed differences between urban and rural areas, indicating no bias.
Suitable measurements sample less than 30% of the global surface. Localities exhibit different temperature trends.	Evidence of warming is apparent in glacier meltings and effects upon ocean salinity levels.
Satellite measurements have global coverage, and can precisely measure tropospheric and stratospheric temperatures.	Short measurement periods, drifts over local solar times, and ozone depletion cooling of the stratosphere skew results.
Balloon radiosonde records are longer and provide accurate tropospheric temperature measurements.	Significant changes in instrumentation and data processing have produced discontinuities over the years.

Temperature Measurement Process Arguments

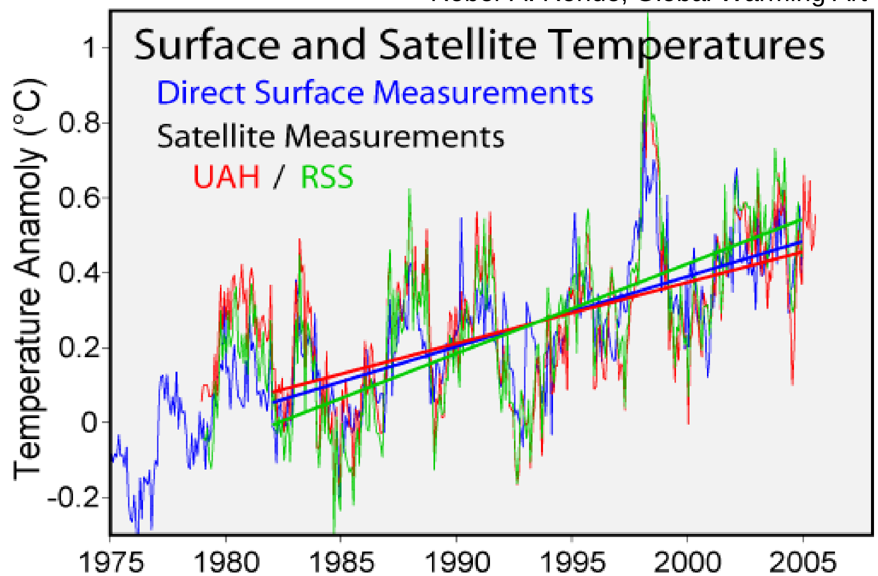
There appears to be a strong consensus among climatological experts that global warming is in fact occurring, and many, but not all, agree that human activities are an important contributing factor.

- An Intergovernmental Panel on Climate Change (IPCC) established in 1988 by two United Nations organizations, the World Meterological Organization (WMO) and the UN Environmental Program (UNEP) supported global warming assertions in a 2001 summary report:

- After much debate, the IPCC concluded that *"In the light of new evidence, and having taken into account the remaining uncertainties, most of the observed warming over the past 50 years is likely to have been due to increases in greenhouse gas concentrations."*

- The Panel also concluded that they expect human activities to continue to change atmospheric composition throughout this century.

Rober A. Rohde, Global Warming Art



Surface ground stations have recorded temperature increases of about +0.11°F (+0.06°C) / decade and +0.31°F (+0.17°C) / decade since 1979, while Remote Sensing Systems (RSS) taken by the U of Alabama Huntsville since 1979 show increases of about +0.063°F (+0.035°C) / decade. Removing RSS measurements of the lower troposphere only to eliminate possible stratospheric cooling effects, the surface and atmospheric measurements may be closer.

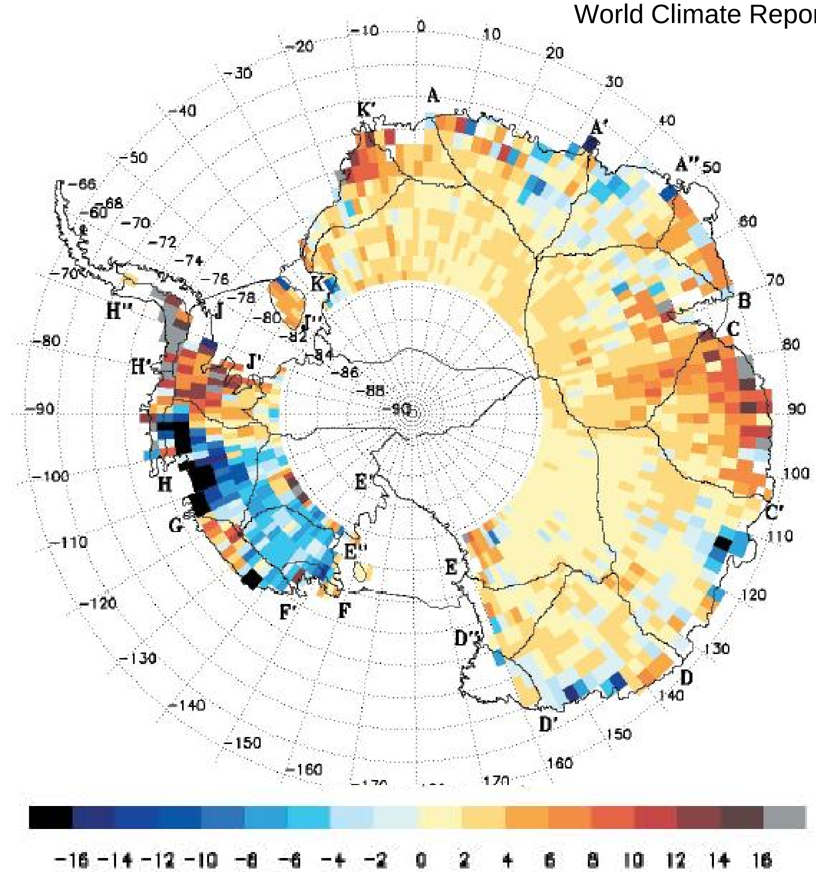
In addition to projecting continued average global temperature increases, the IPCC also predicted that sea levels will rise "under all scenarios".

• Given that rising sea levels are principally associated with anticipated Arctic and Antarctic ice melts, measurements of snow accumulations in Antarctica may offer an alternative picture:

- Satellite altimeter measurements made between 1992-2003 indicate, on average, the elevation of about 3.2 million square miles (8.5 million square kilometers) of the Antarctic interior has experienced a net snow gain of about 38.-52 billion tons/year, potentially enough to slightly lower the surrounding sea level.

- These observed snowfall increases covering about 70% of the total ice sheet area are likely to be linked to warming of southern oceans from either natural or human-influenced causes.

World Climate Report



Rate of Elevation Change (cm / year) from 1992 – 2003 Determined by Satellite Altimeter Measurements (from Davis, et al., 2005).

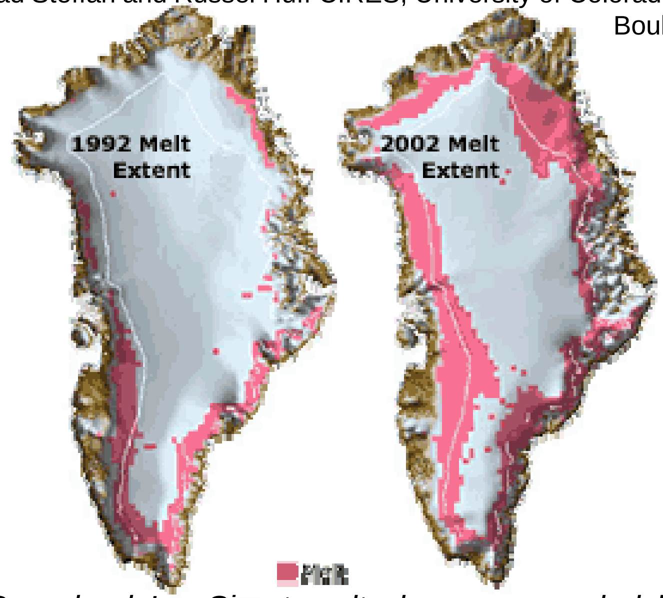
Snow Accumulation in the Antarctic Interior

European Space Agency satellite altimeter measurements of the Greenland Ice Sheet since 1992 record recent changes similar to those observed in Antarctica, with thickness growth in higher interior areas, and thinning at coastal margins.

- While total mass balance gains or losses are yet unknown, spatial averaging indicates a net increase of 2.1 in (5.4cm) per year, with thickness increases of about 2.5 in (6.4cm) per year in interior areas above 4,900 feet (1,500 meters), and 0.79 in (2 cm) per year reductions below that elevation:

- The recording period is too short to know if these observations represent a long-term trend, since Arctic temperatures appear to naturally fluctuate in 60-80 year time cycles.
- Annual snowfall increases and melts have been observed to be strongly linked to variability in regional atmospheric circulation (the North Atlantic Oscillation), along with possible smaller influences associated with temperatures.

Konrad Steffan and Russel Huff CIRES, University of Colorado at Boulder



Annual Greenland Ice Sheet melt changes revealed by satellite data since 1978 are believed to be largely influenced by regional atmospheric circulation patterns and conditions. Comparable lower-than-average total melts occurred in 1992 and 1996, and similar higher-than-average melts occurred in 1991, 2002, and 2005. Warming (from natural and human-enhanced influences) may be a contributing factor. The lower-than-average 1992 melt appears to be linked to a large Mt Pinatubo eruption that released aerosols.

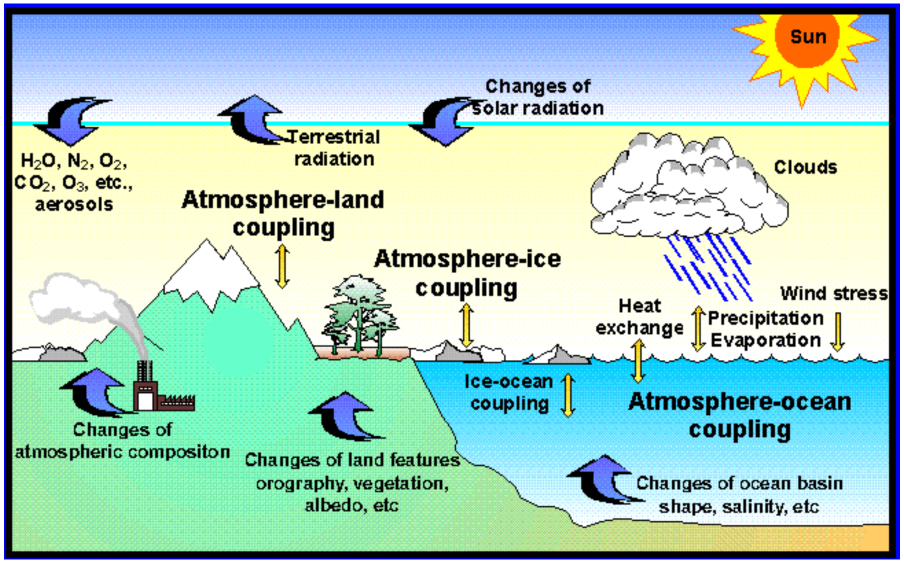
Greenland Ice Sheets

Contrary to IPCC conclusions that all global warming scenarios inevitably lead to sea level increases, the Antarctic and Greenland observations demonstrate apparent exceptions.

- However a caveat in the IPCC report acknowledged the potential fallibility of current climate prediction models, stating that: "*Such models cannot yet simulate all aspects of climate (e.g. they cannot account for the observed trend in surface-troposphere temperature changes since 1979) and there are particular uncertainties associated with clouds and their interaction with radiation and aerosols*":

- It is widely recognized that while computer simulations do provide scholarly tools, they contain substantive uncertainties, and cannot accurately reproduce many climate features.

CSIRO Marine and Atmospheric Research



Weather is influenced by many interactive day-to-day conditions and events in a locality that are often difficult to predict with confidence. Global climate is conventionally thought to be comprised of interactive local weather conditions over large scales measured over 30 years or more, adding enormously greater complexities and uncertainties.

Climate Modeling Challenges

Strongly influenced by the IPCC report, the Kyoto Protocol was established by the UN, and requires participating industrialized nations to reduce emissions of CO_2 and five other greenhouse gases (GHGs) by 5.2% under 1990 levels between 2008-2012.

- The US and Australia have believed certain provisions to be unrealistic and unfair, including exemptions for China and India, terms that enable the EU and Russia to trade GHG emission credits within regional countries, and advantages to previously very polluted nations:

- The EU is believed to have a large advantage because German reunification eliminated many dirty East German industries, a circumstance that also applies to Russia following the collapse of the USSR.

- The UK has an advantage following the discovery of a large North Sea natural gas deposit that enabled a major coal phase-out.

CNN

The Kyoto Protocol was established under the UN's Framework Convention on Climate Change (UNFCCC), and became active in 2005 following ratification by Russia.

Arguments Against:	Arguments For:
Protocol is uneconomical, subjective, inequitable and ineffective.	Costs for non-compliance may be higher than failures to act.
It excludes the largest future CO_2 emission sources (China and India)	Largest share of past / current emissions are from developed nations.
Exclusion of developing countries is unfair to developed ones.	Developing countries need to grow their industries for social needs.
Basing upon per capita emissions (not total) is unfair to Australia.	Per capita emissions in developing countries are relatively low.
Emission credit trading within the EU is unfair to single nations (the US).	If the US doesn't participate, it will have economic advantages over the EU.
The UK, Russia, and Germany have advantages due to high 1990 levels.	The US is currently the largest CO_2 emission producer.
The 2008 effective time scale is insufficient to meet compliance.	Reducing CO_2 emissions is crucially important to reverse global warming.
The CO_2-global warming connection isn't clear, but economic impacts are.	The UN and some individual national scientific groups favor the Protocol.

Key Kyoto Protocol Provision Issues

Neither the Clinton nor Bush Administrations have found terms of the Kyoto Protocol acceptable.

- These positions follow a policy established through unanimous passage of a July, 1997 Byrd-Hagel US Senate Resolution (S. Res. 98) which stated that the US should not be signatory to any protocol that does not include binding targets and timetables for both developing and industrialized nations or "*would result in serious harm to the economy of the United States*":

- Although Vice President Al Gore symbolically signed the Protocol, the Clinton Administration never submitted it to the Senate for ratification.

- President Bush has indicated that he also doesn't plan to seek Senate ratification, not only because of the China and India exemptions, but additionally because of strains it would put on the economy and uncertainties regarding climate change assertions.

The Byrd-Hagel Senate Resolution 98 Vetoed Kyoto Protocol Terms

Neither the Clinton nor Bush Administrations Sought Kyoto Senate Ratification

Bi-Partisan Kyoto Rejection

Objections to specific terms of the Kyoto Protocol were based upon a variety of economic arguments, and environmental concerns:

- The 2008 compliance completion date mandated by the Protocol would force an unrealistic schedule for retiring and replacing energy technologies since the typical lifetime of a power plant is about 30 years, and the average US automobile is on the road for 11-12 years.
- Some scientists argued that certain environmental provisions were misguided, such as providing credits for planting forests to sequester carbon, but doing so in a way that would offer economic incentives to destroy wetlands, potentially creating excess CO_2.
- Some climatologists argued that real effects upon climate change would be virtually nonexistent since an estimated 2% - 3% emission reduction would be within the natural margin of error, and trivial compared with natural carbon sequestration by the marine and terrestrial biosphere.

Technology Phase-Out Schedule

Destruction of Wetlands

Economic and Environmental Issues

Establishment and enforcement of universal international environmental protection standards has thus far proven to be an elusive goal.

- The Kyoto Protocol, now ratified by 163 countries, reflects common priorities but perhaps little real progress:

- The US and Australia have declined to ratify, arguing that the maximum greenhouse gas emission limits are unrealistically restrictive and costly to meet.

- Of all ratifying countries, only 31 are actually required to lower greenhouse emissions, and China and India with huge populations, exploding industrial growth and enormous pollution problems are among those excluded.

- Europe and Japan are struggling to meet the greenhouse restrictions, while Canada has given up entirely.

- Germany has exempted its coal industry from compliance.

Planetsave

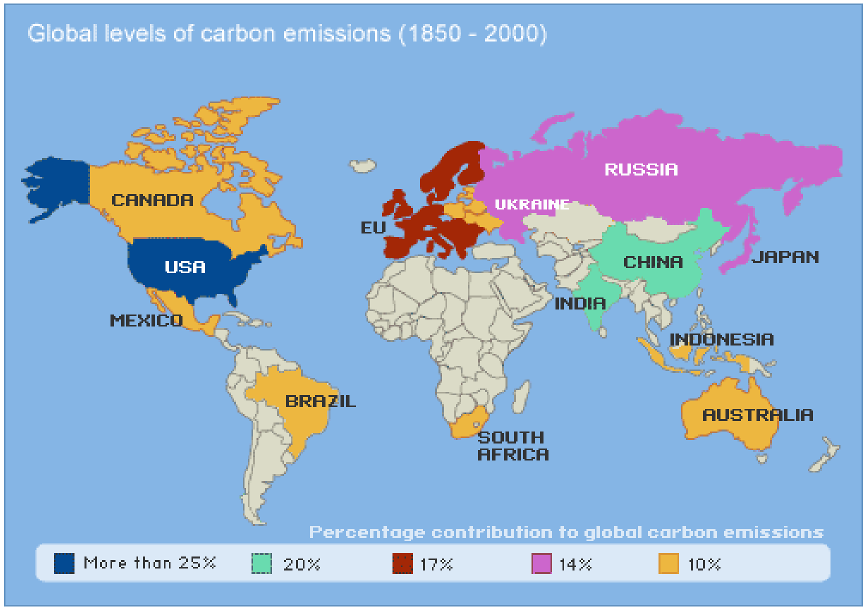
Pursuing International Solutions

As contentious debate among public and private groups continues within the US and other countries regarding merits and faults of the Kyoto Protocol, many ratifiers and refrainers are working to pursue more satisfactory agreements.

- The US and Australian governments are signatories of an "Asian Pacific Partnership on Clean Development and Climate" sponsored by an Association of Southeast Asian Nations (ASEAN) regional forum in 2005 which enables countries to set voluntary GHG reduction goals:

- Other participating countries include China, India, Japan and South Korea who ratified the Kyoto Protocol.
- The US hopes to fulfill a pledge to reduce CO_2 emissions 18% by 2012, and the pact also appears to be gaining favor in Canada which now recognizes an inability to meet its Kyoto targets.

BBC



The US currently heads the world in CO_2 emissions. China is adding about one new coal-fired power plant per week, plans to do this for the foreseeable future, and is expected to be the largest GHG emitter within a few years.

Beyond the Kyoto Agreement

Interjections of economic considerations into national and international environmental policy decisions can be regarded by some as an inevitable compromise of principles.

• Recognizing that all-too-often these separate priorities have produced conflicts, with environment the loser, it is also important to realize ways the underlying objectives of both are interdependent:

- Commercial investment, production and profits provide employment essential to support families of all income levels, finance education and public services, and create safe and affordable energy and food used in daily life.
- Businesses that fail, or are forced to relocate to countries with lower environmental standards, compound economic stress with additional global environment impacts.
- Economic prosperity reinvested by industry provides cleaner, more efficient production methods, products and advancements.

Larry Bell

• Establish a responsible balance between economic and environmental interests, ensuring that both are fully and effectively represented in policy and finance decisions.

• Provide incentives and regulatory mechanisms that promote clean industries without imposing overly burdensome costs and restrictions that send production and jobs overseas to places that lack equivalent environmental standards.

• Protect national competitiveness in world markets through international agreements that insist upon fairness, while also demonstrating that global cooperation benefits everyone.

• Recognize responsibilities of all nations to support less developed ones through technology funding and transfer for climate-related studies and projects.

Economic Policy Priorities and Challenges

Many very intelligent, highly-educated and extremely dedicated people share real concerns about climate change, yet sharply disagree about specific causes, impacts and solutions.

- Such varying perspectives and opinions are powerful motivators that drive innovative ideas, exploration into new areas of investigation, and development of improved research methods and tools:

- The fact that these differences are often passionately debated reflects the enormous importance attached to their concerns, and deserves to be honored with appreciation and respect.

- Real progress demands that theories be regarded as unproven possibilities, and "established facts" be constantly tested as newer, more comprehensive information is revealed.

Larry Bell

Less Concerned	More Concerned
Climate models have proven faulty and don't include major influences.	Humankind is performing a dangerous geophysical experiment.
Human vs. natural contributions to atmospheric CO_2 are very small.	A precautionary principle requires action to prevent crises later.
CO_2 levels follow a temperature rise, not the other way around.	Temperatures and CO_2 have risen rapidly over the past 50 years.
Temperatures always rise and fall during interglacial periods.	Most scientists today share global warming concerns.
Issues are politicized; climatologists who disagree are afraid to speak out.	Most scientists agree that human activities contribute to warming.
CO_2 is a very minor greenhouse gas, and most comes from natural sources.	CO_2-water vapor interactions can have a compounding effect.
Natural ocean and land CO_2 sinks rapidly reduce accumulations.	CO_2 has a long average atmospheric lifetime.
Solar activity is a major factor: present levels are highest in 8,000 years.	Without greenhouse forcing, solar activity doesn't account for changes.
Greenland/Antarctica melts are balanced by interior snow accumulations.	Greenland/Antarctica melts may flood global coastlines.
Global warming may have prevented an overdue new ice age.	Greenland melts may trigger a Northern Hemisphere glacial event.

How Concerned Should We Be About Global Warming/CO_2?

Honoring Disagreements

Wide-spread concerns about global cooling trends during the 1970s and warming in the present may have a solid basis (possibly in reverse order), but even then do not necessarily warrant dire catastrophic forecasts.

- There are no conclusive reasons to believe that slightly lower temperatures are preferable to slightly higher ones, or that modest warming trends will trigger runaway greenhouse events:

- Recognizing that atmospheric and surface climate mechanisms may well be sensitive to relatively small influences, CO_2-water vapor interactions linked to greenhouse feedback loops do appear to be less active than climate models formerly suggested.

- It is also apparent that much of the CO_2 released from human and natural processes is absorbed by the oceans and terrestrial biosphere, providing an essential nutrient for agriculture, forests and all plant-based ecosystems.

Human Influences:

- What levels of greenhouse gas emissions are significant?
- How important is CO_2 as a greenhouse gas?
- What are other human forcing factors and interrelationships?
- How significant are fossil fuel combustion influences?
- Can switches to biofuels and other alternatives make measurable differences?
- How important are land use change influences?

Effects and Concerns:

- How warm is ultimately “too warm”?
- Is current warming a natural micro-trend within this present interglacial?
- When is the next ice age “scheduled” to arrive?
- Are net Arctic / Antarctic water mass balances changing?
- Will Northern Atlantic salinity dilution trigger cooling?
- What human greenhouse gas reductions are possible / realistic?

Global Warming Questions

It is rational to recognize global warming as a current reality that can possibly precipitate non-linear sudden climate shifts.

• A 2002 report titled "Abrupt Climate Change: Inevitable Surprises" issued jointly by the Ocean Studies Board, Polar Research Board, and Board on Atmospheric Sciences and Climate of the National Research Council advocated preparation without panic:

- "*The climate record for the past 100,000 years clearly indicates that the climate system has undergone periodic and often extreme shifts, sometimes in little as a decade or less*"… "*Societies have faced both gradual and abrupt changes for millennia and have learned to adapt…*"

- "*It is important not to be fatalistic about the threats of abrupt climate change*"… "*Nevertheless, because climate change will likely continue in the coming decades, denying the likelihood or downplaying the relevance of abrupt changes could be costly*."

Larry Bell

Complacency, possibly rooted in denial or apathy, promote hazardous tendencies to assume that "everything is really fine"; or "someone else will solve the problem"; or it won't happen in my lifetime or anytime soon, so why worry?"

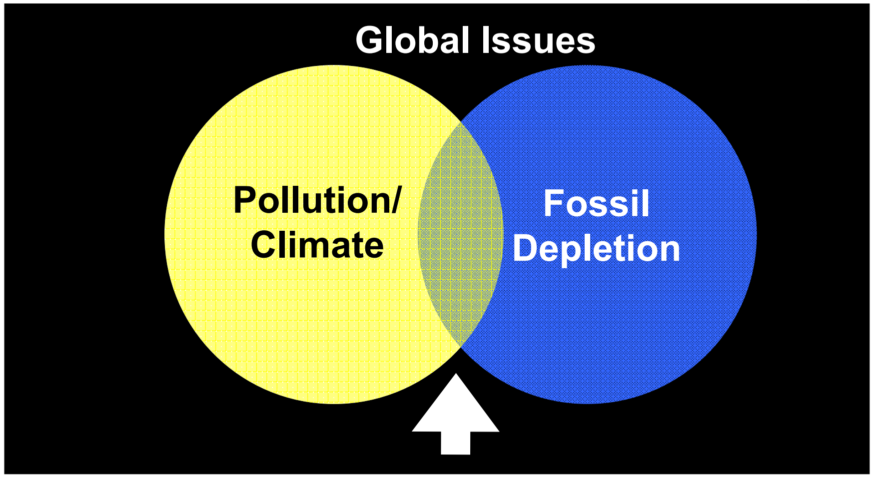
Hysteria, potentially fueled by simplistic assumptions and sensationalism can promote desperate, misguided and costly decisions at the expense of seeking better understanding of underlying issues and pursuing the most effective intervention options.

Dangerous Extremes

The "Abrupt Climate Change: Inevitable Surprises Report" issued by the National Academy of Sciences in 2002 emphasizes that "Increased knowledge is the best way to improve the effectiveness of response; research into causes, patterns, and likelihood of abrupt climate change can help reduce vulnerabilities and increase our ability to react."

The fact that theories and models do not always match measured observations does not necessarily indicate that basic underlying premises are wrong, that predicted outcomes are invalid, or that reasoned interventions should be delayed until all conditions are perfectly understood.

- There is inescapable evidence that human activities are changing Earth's environment, including its climate, in ways that pose unacceptable perils to all life:
  - Air, water and land pollution is an expanding global reality that must be rapidly reversed before the impacts are irreversible.
  - Fossil fuel depletion is a near-term certainty that demands a greatly accelerated adjustment of consumption habits and transition to clean, sustainable alternatives.



Information:
Determine interrelationships between causes / effects and human contributions / interventions.

Education:
Disseminate accurate information to advance public, industry, and government awareness.

Innovation:
Develop responsive technologies, strategies, and programs that address short- and long-term needs.

Application:
Put responsive plans and technology infrastructures into action through national and global initiatives.

Responsive Priorities

The emergence of Homo Sapiens from the Late Pleistocene glacial period about 13,000 years ago demonstrated our remarkable human capacity to adapt and survive.

- Since that time humankind has achieved much, beginning with stone tools, and ultimately returning similar rocks during expeditions to the Moon:

- Our genus has learned not only how to adapt to the environment, but through agriculture, industry and living, to adapt the planet to serve human purposes.
- We are now realizing that our continued survival will depend upon learning how to protect the planet from our impacts, probably the greatest adaptation challenge of all.

Chemistryland
NASA

Chemistryland
NASA

Applying Knowledge and Tools

Our human capacity to gain knowledge about changes we are imposing upon our planet provides opportunities to adapt our living habits, industries and technologies to prevent events unscheduled by Nature from creating unfortunate and avoidable surprises.

- Such events, including resource exhaustion, ecosystem destruction and severe climate changes can have harsh consequences effecting all life:

- Rapid changes, even lasting over relatively short periods, can be more hazardous and disruptive than slow ones, allowing less time to respond.

- Unlike our early ancestors, we won't be able to simply "pack up and leave", since there may be few places to escape to, and it may be impossible to relocate present large populations to more favorable areas, particularly across restricted national borders.

Scientific American
United Nations Magazine

European Space Agency
Vestal Design

Penalties for Failures

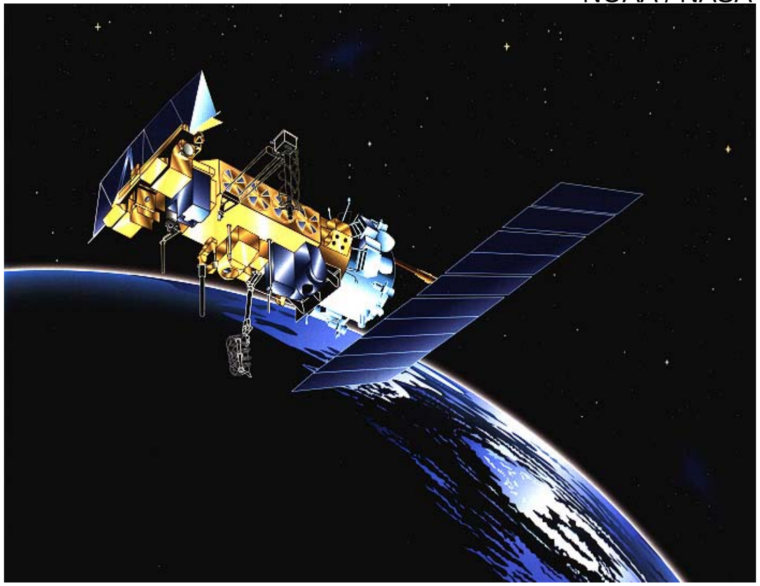
International researchers from diverse disciplines using a variety of new tools are making real progress towards achieving a better understanding of natural and human-enhanced influences upon Earth's environment and climate.

- Increasingly precise methods are being used and improved to measure distant and recent climate and temperature fluctuations, and to assess observed and potential influences upon atmospheric and surface phenomena and their interactions:

- Expedited advancement and expanded application of these capabilities is vitally important to construct more comprehensive and reliable climate models, both to examine current forcing conditions, and to predict future trends and consequences.

- Rapid advancements in computing technologies are also encouraging, and are critically important to study enormously complex interrelationships between forcing influences that are continuously being revealed.

NOAA / NASA



NOAA Polar-Orbiting Operational Environmental (NOAA-K) Satellite

Information Advancements

Information technology is but one of many tools afforded to guide better understanding of Nature’s complexities and intricacies, our influences upon these phenomena, and lessons we can apply to be more positive contributors.

- Other important tools are our natural gifts of human curiosity, reasoning, creativity and the capability to recognize our dependence upon the wellbeing and stability of other creatures, habitats and support systems that our actions impact:

- As students of Nature and Earth’s history we learn that very large events and consequences can precipitate from small compounding influences over relatively short time frames.

- We can also readily observe that pervasive human influences upon this plant’s fragile lands, oceans and atmosphere are neither small nor sustainable.

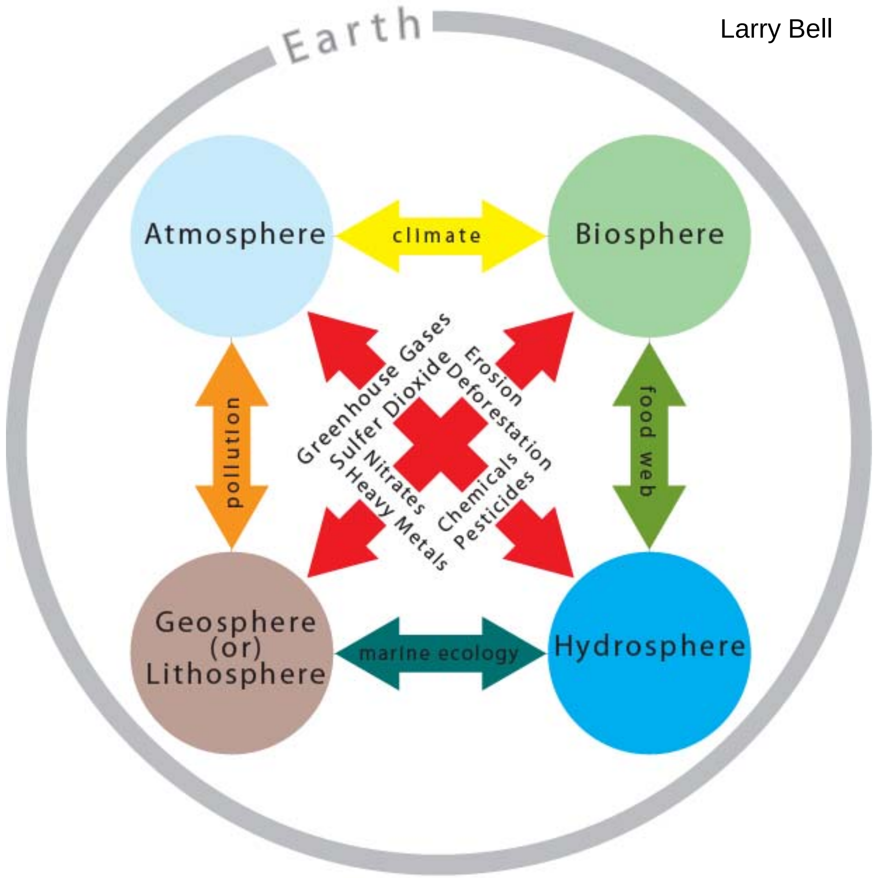
Asel Electronic
NOAA

RST3
Welfare Service Club

Lessons from Experience

The spheres of influence that impact life on our planet are always in a dynamic, complex and delicate state of balance.

- Human activities clearly impact the equilibrium of these influences, and are doing to at an accelerating rate:
  - During the past two centuries we have switched from biomass energy to fossil fuels for more than 90% of industrial energy, releasing CO_2 that has been stored for millions and billions of years.
  - Toxic pesticides created to increase food production needed to support growing world populations has entered sensitive marine ecosystems.
  - Nitrates and particulates released from combustion are polluting the atmosphere.
  - Short-sighted agricultural, mining and deforestation practices have sacrificed topsoils, leached chemicals into land and water, and effected the oxygen-CO_2 balance.



Contributions to Global Changes

There is little disagreement within our global community that we must change the ways we treat our natural environment before it retaliates in ways we cannot correct.

- Whether these repercussions occur rapidly or over longer time frames, present trends are unsustainable, promising unthinkable consequences that transcend geographic boundaries:

- Citizens, children and future generations throughout the world are equal stakeholders in the outcomes of our actions.

- Industrialized and developing nations enjoy special responsibilities and opportunities to provide essential solutions and examples.

- Our decisions and commitments may well determine the ultimate destiny and natural legacy of human civilization.

Our Legacy

Viewed from vantage points of our everyday lives it is convenient to perceive the world as an open and unbounded place with limitless self-healing ability and resource abundance.

- From this perspective we may be even more inclined to view ourselves and our communities as small, isolated parts of overwhelmingly large systems and events where our actions are inconsequential or futile:
  - Everything, including the weather, comes from "somewhere else" and we have no effect upon it.
  - If we lack adequate supplies of something we can find them "somewhere else", or eventually substitute other things that will work as well or even better.
  - We might imagine that adverse changes in our environments will occur slowly and reversibly so that we can afford to worry about them later.

Larry Bell/ Candy Feuer

Living Only In the Here and Now

Gazing upwards towards the night sky, none of us alive today in "developed" regions, other than astronauts who have orbited above our small globe, have witnessed the bright and expansive starfields that our ancestors observed a few generations past.

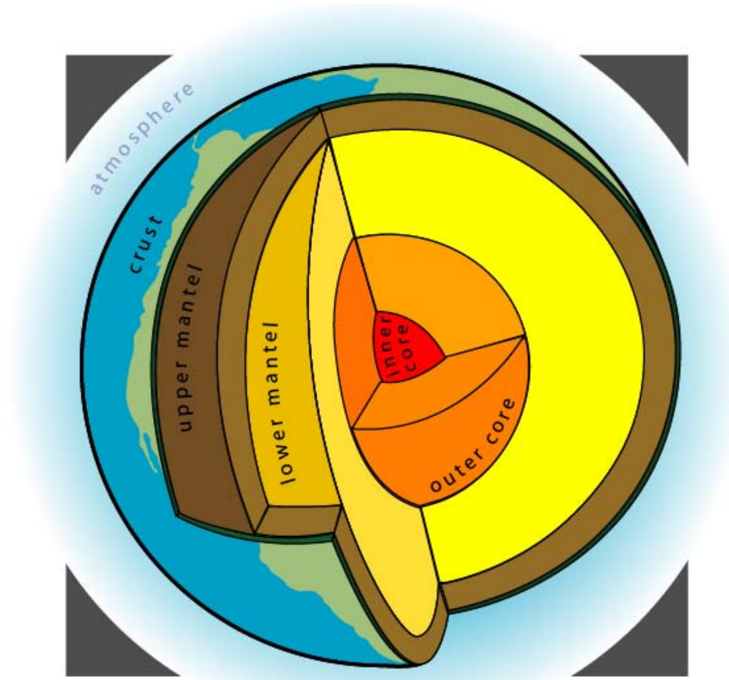
- Lacking such a reference of change, and with views obscured by atmospheric pollutants, we may often lose sight of important realities:
  - We may be unaware of the extent and rate our activities are effecting essential life support systems.
  - We may tend not to recognize that what every community on Earth puts into the atmosphere (and oceans) is rapidly distributed through natural transport to global destinations.
  - We may often forget that nature mixes all environmental influences together with combined and interactive consequences.

NASA

Larry Bell/ Candy Feuer

Due to our visual inability to perceive depth of the atmosphere that surrounds us we may often fail to recognize its limited dimension.

- Using the Earth as a reference, that fragile life support layer is indeed very shallow.
  - Compared with our planet's radius of approximately 6,400km (4,100 miles), 99% of Earth's atmosphere is contained within a layer only about 50km (31miles) thick.
  - All life on Earth inhabits a layer no more than 9km (5.6 miles) thick, extending from a few kilometers above sea level (airborne organisms and life on mountains) to a few kilometers below (deep ocean creatures and subterranean microbes).

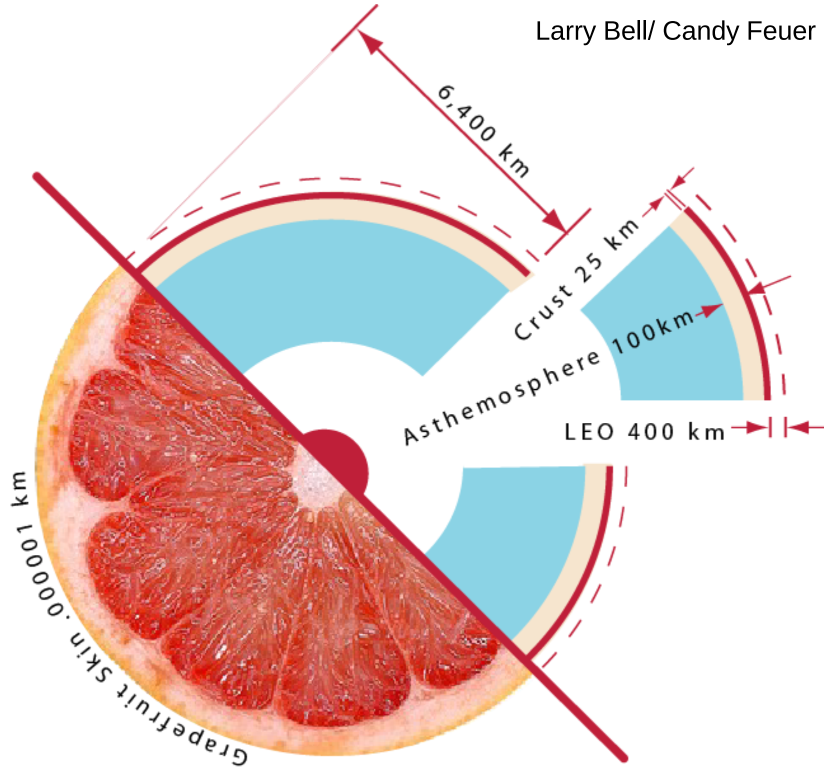


Earth Layers	Depth	Thickness
1 inner core	-6378 km	1216 km
2 outer core	-5150 km	2270 km
3 lower mantel	-2981 km	2900 km
4 upper mantel		
5 crust	0 km	5-70 km
6 atmosphere	50 km	50 km

Larry Bell/ Candy Feuer

Moving farther out into "space" at an altitude where space stations orbit, we continue to find ourselves well within Earth's immediate territorial border.

- Using the proportions of a grapefruit to put dimensions into perspective we are now only moving about the outer skin surface:
  - Low-Earth Orbit (LEO) at a distance of about 250 miles (400km) is less than 5% of Earth's radius away.
  - Earth's atmosphere estimated to extend outward from the surface to about 62 miles (100km) represents about 1.5% of the radius (the inner grapefruit skin).
  - Earth's crust, which constitutes all solid structures, extends inwards about 15 miles (25km) (about 0.4% of the radius) barely penetrating into the grapefruit's juicy part.



(Distance Reference: Earth/LEO vs. Grapefruit)

From LEO we observe a dynamic Earth where forces of nature and consequences of human activities connect, interact and often collide.

- This view reveals the contiguous surface of our planet, where the only real boundaries between human nations and jurisdictions are defined only by land features and water bodies.
  - Weather forces form windswept patterns that rapidly circumnavigate the globe, distributing water and dispersing contaminants along their paths.
  - Storm runoffs and river currents transport topsoils and chemicals to marshlands and estuaries for deposit as sediments, or transfer to more distant locations by ocean tides.

NASA

NASA

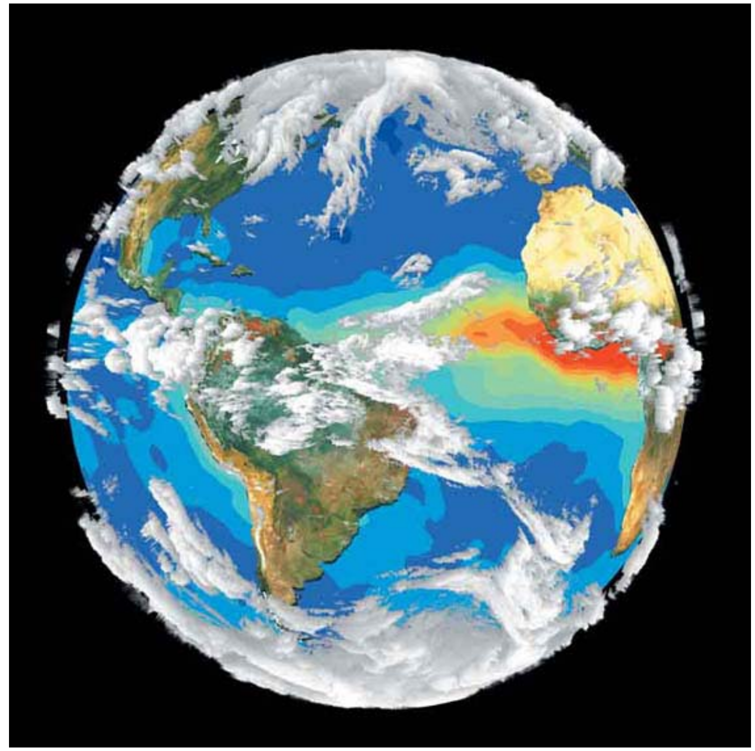


Image created using data from four satellites, showing fires burning on land areas, a large aerosol cloud over the Atlantic Ocean formed by biomass burning in Africa, and a dust cloud surrounding the globe.

Earth viewed from space makes us realize that we are all members of a global civilization aware of impacts that our common community has upon our planet and our future.

- Pollutants from all parts of the world rapidly circumnavigate through the atmosphere and oceans to distant locales, and weather and climate influences recognize no geopolitical boundaries:

- Environmental abuses everywhere are ultimately visited upon us as our problems, as are those we export to others.

- Interventions we enact, while important, offer only marginal protection from cumulative impacts of other nations, including contamination of marine ecosystems we share and the air we breathe.

- It is clear that just as the problems are global, real solutions must be also.

Viewing our tiny, fragile planet from space we can more fully realize that there is really no "them", only us, and that we must learn to live and work within that sphere of reality.

- Our world, shared with other creatures, is a place of overwhelming, magnificent complexity:

- It is a place within an infinitely larger Universe where marvelous, often poorly-understood natural forces interact and exchange energy at unimaginably large and small levels of scale.

- It is place where global and microscopic events occurring over millennia and microseconds cause some creatures to evolve, while others unable to adapt perish.

- It is a place where societies bound together by common purposes and dreams sometimes become separated by conflicts that impact our lives, future and planet.

NASA

Candy Feuer

A realistic and resourceful world view recognizes that each and all of us are integral parts of Nature and that it constitutes what we are made of.

- This perspective makes no distinction or excuse regarding size since elements and actions at all levels of scale are connected:

- Being parts of an unimaginably large and marvelous Universe empowers rather than diminishes us (and everything is tiny compared to the Universe).

- Small actions and examples can bring about large effects by establishing precedents for others to participate.

- Almost nothing in Nature can be truly isolated from an influence upon everything else.

- In Nature, everything is part of everything, including us and our individual actions.

Everything is Small Compared to the Universe, and Everything is Important