# CLIMATE CHANGES:

## THE CONDITIONS, CAUSES, AND CONTROVERSIES

**LARRY BELL**

Wm. Robert Johnston

## Is global warming really occurring?

**Yes. The planet has been gradually warming for about 18,000 years since the last Ice Age.**

**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".**

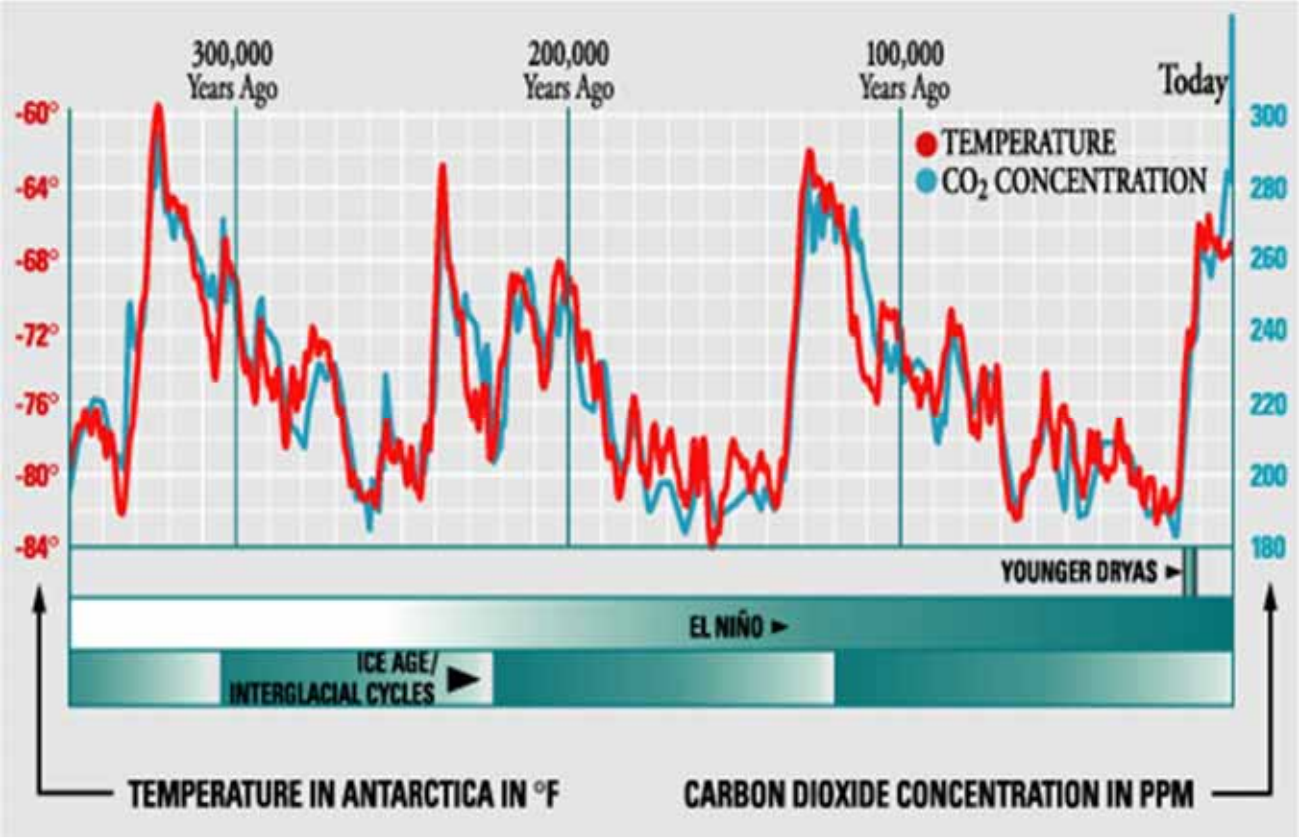
***The Last Ice Age, About 16,000 BC***

## How warm is too warm?

**That depends upon your perspective vs. a long-term view of natural cycles.**

**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 witnessed changes when huge glaciers have destroyed entire regional ecosystems and altered topographical surface features.**

Maria Koshland Museum of the National Academy of Sciences




***Glacial and Interglacial Cycles***

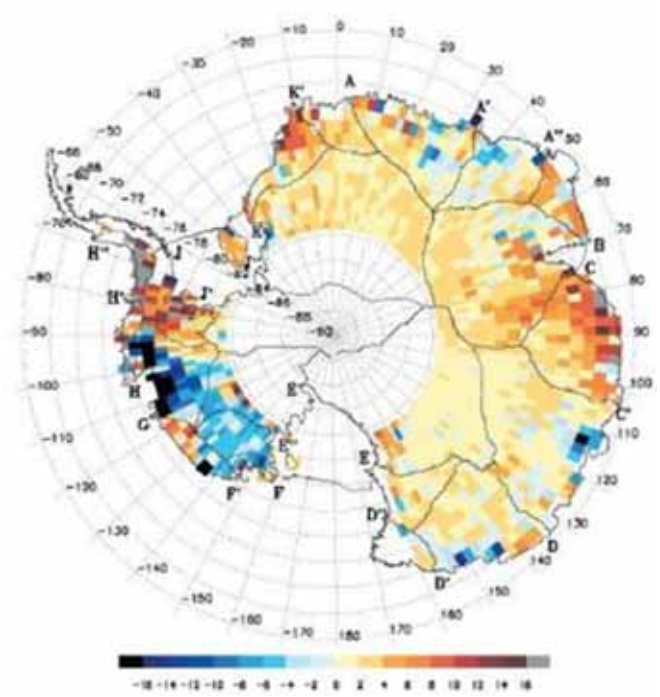
**CLIMATE CHANGES** **EARTH'S HISTORY**

**But aren't polar ice caps melting? And won't continuing melts of Antarctica and Greenland flood coastal urban areas?**

**This is far from certain.**

**Antarctica melting (primarily in western coastal areas) appears to be offset by snowfall water mass accumulations on the eastern coast and interior areas resulting from increased evaporation / precipitation.**

**The net water mass gain or loss is unclear based upon recent satellite altimeter measurements since 1992.**



***Snow Accumulations in the Antarctic Interior***

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

***Antarctic Ice Sheet***

**CLIMATE CHANGES** **POLAR CONDITIONS**

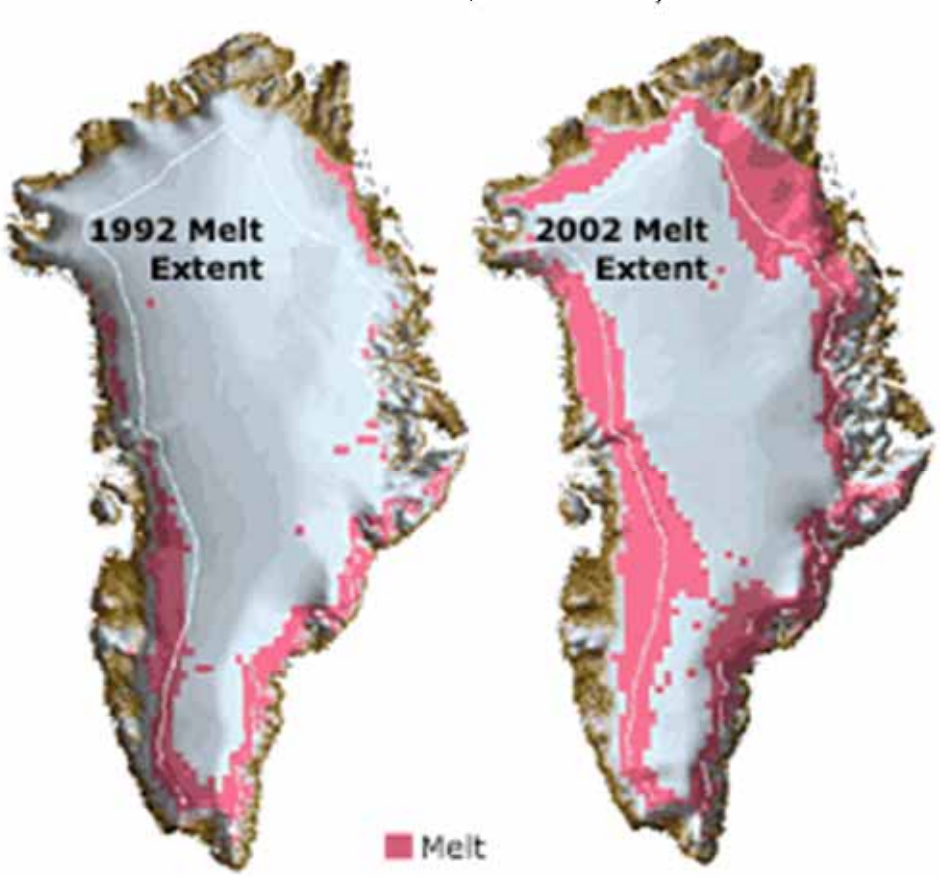
Konrad Steffan and Russel Huff, CIRES University of Colorado at Boulder

**Similar to Antarctica, Greenland coastal ice melts are also offset by interior snowfall accumulations.**

**Seasonal / Yearly melts and gains fluctuate considerably and longer-term trends are believed to follow 60 – 80 year cycles.**

**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.**

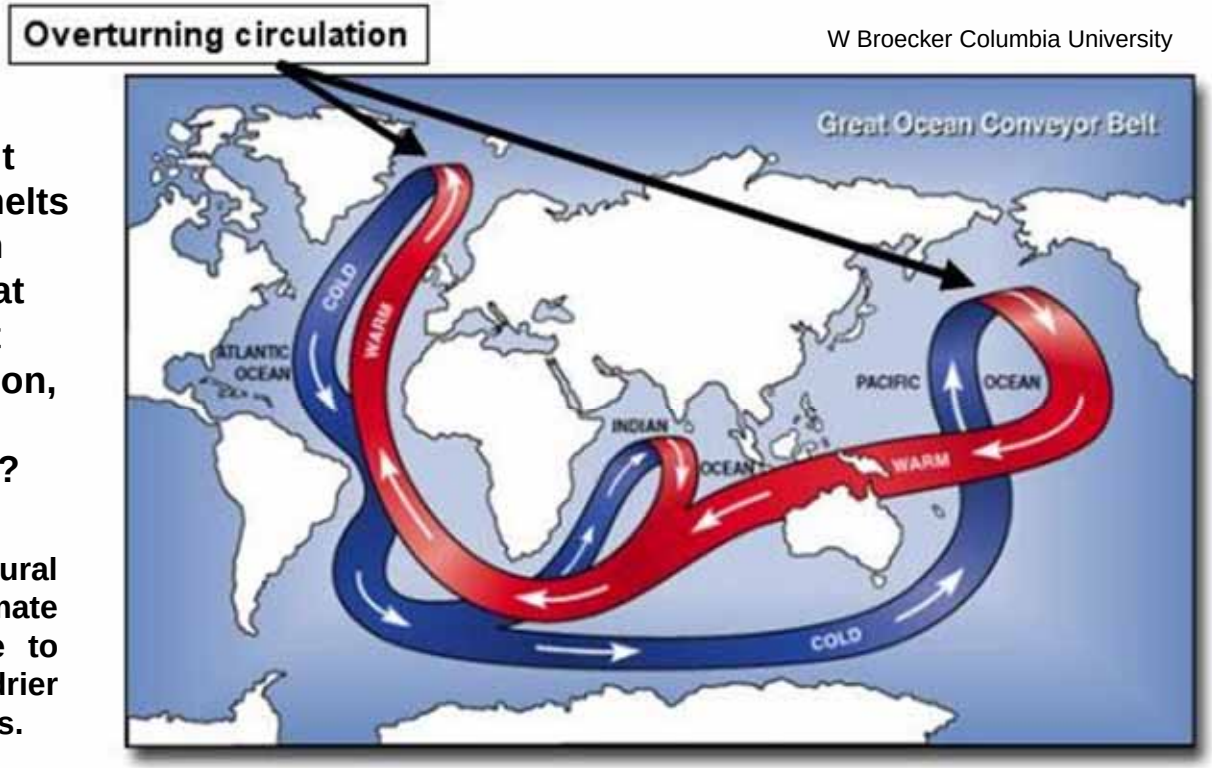



*Greenland Ice Sheets*

W Broecker Columbia University

**Even if oceans don't rise, what about reports that Greenland coastal ice melts are producing large "rivers" of fresh water in the North Atlantic Ocean that are likely to interfere with the "Great Conveyor" of thermohaline convection, blocking tropical water that flows northward to warm northern Europe?**

**History has demonstrated that natural interglacial cycles cause regional climate shifts from time-to-time, causing some to become warmer or colder and wetter or drier to the advantage or disadvantage of others.**




**Thermohaline Convection ("The Great Conveyor")**

Some scientists theorize that freshwater melts from Arctic ice might shut down thermohaline circulation that powers heat transfer from the tropics to Europe in winter. This might cause a sudden drop in North Atlantic water temperatures to bring colder temperatures to land masses on both sides.

***Possible Mini-Ice Age Warming Trigger***

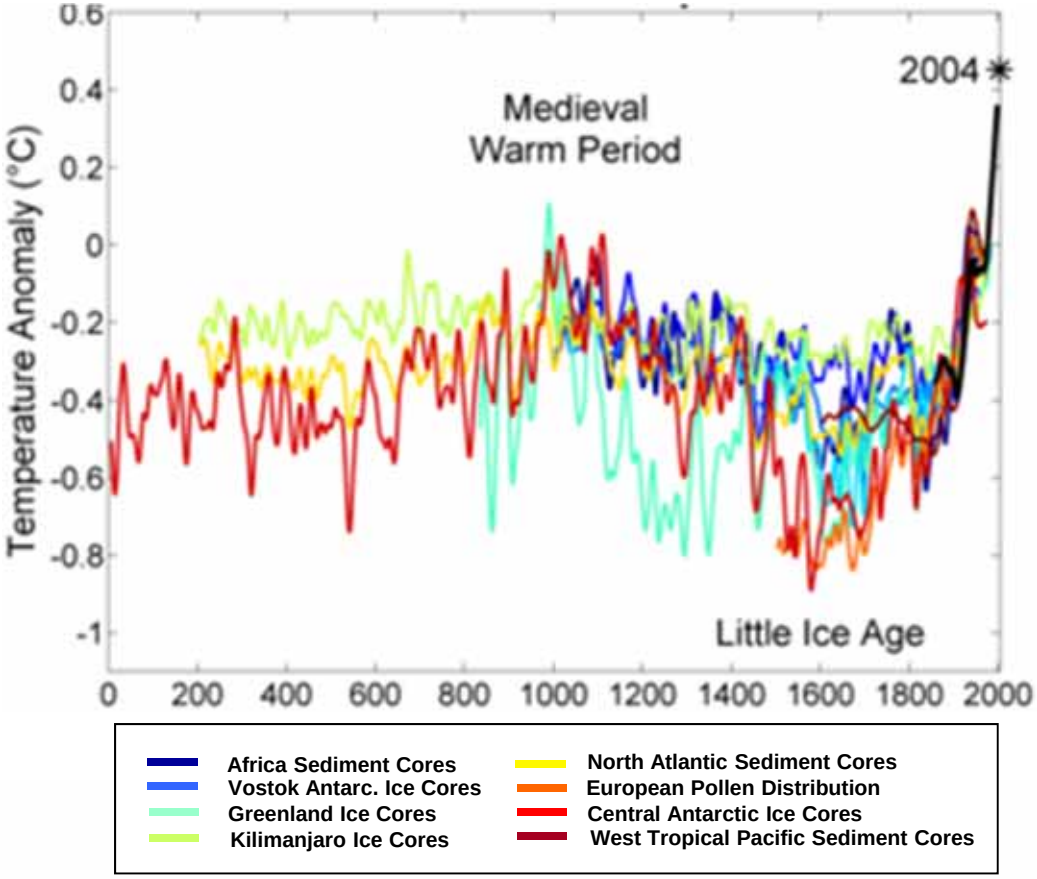
**CLIMATE CHANGES** **POLAR CONDITIONS**

Robert A Rhonde, Global Warming Art

**Isn't Earth the warmest it has been over thousands of years?**

**Today's climate is similar to the "Medieval Warm Period" that occurred between about 1000 – 1200 AD, which was immediately followed by the "Little Ice Age" that lasted about 400 years between the 16th and 19th-centuries.**

**Many people believe that the Northern Hemisphere is still warming its way out of the Little Ice Age (not a true Ice Age) and will soon enter a real Ice Age.**




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

***Earth Climate Changes (Past 2000 Years)***

**CLIMATE CHANGES** **INTERGLACIAL FLUCTUATIONS**

Hendrick Avercamp, Painter

**Interglacial periods are characterized by rapid and dramatic climate shifts.**

**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.**

***Scene inspired by the harsh winter of 1608 in The Netherlands***

***Little Ice Age Cooling Paradox***

NASA Goddard

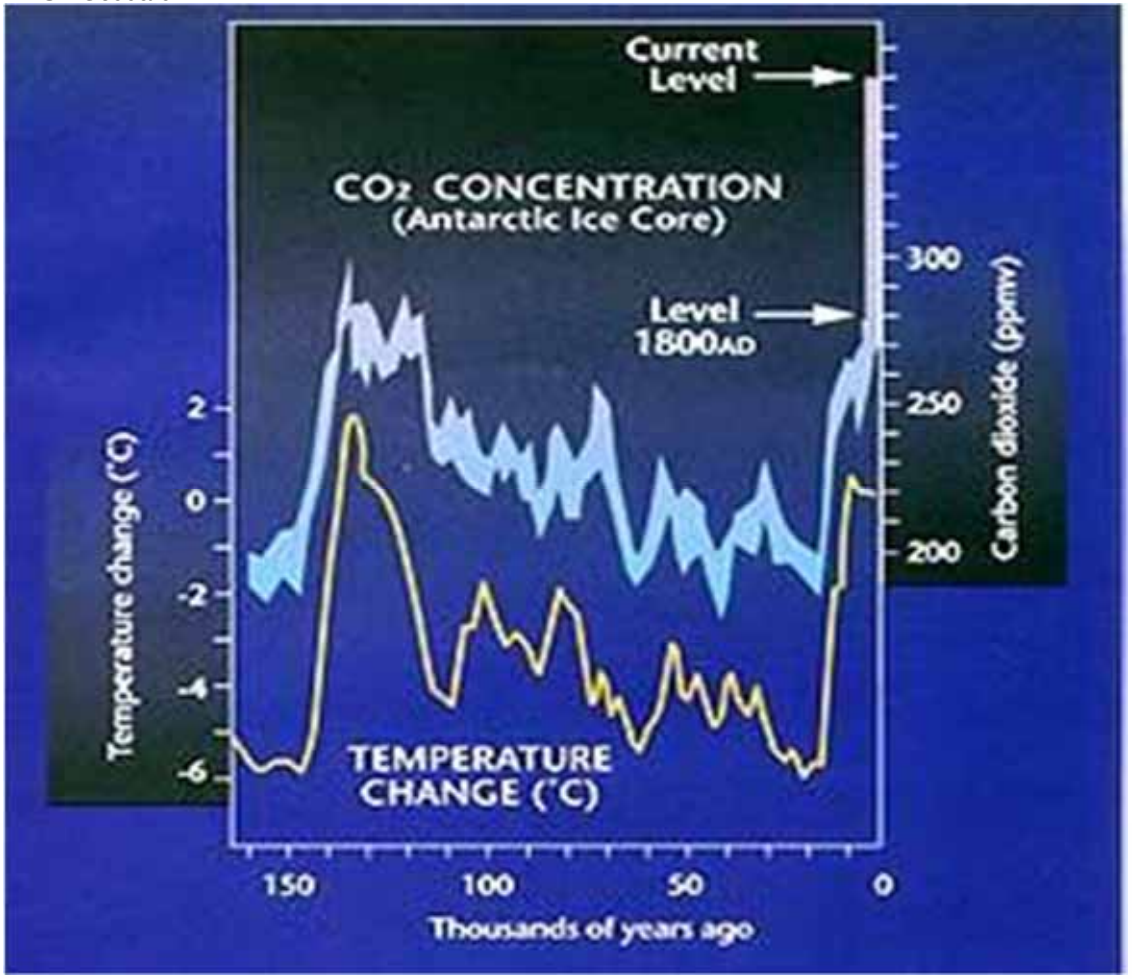
**Evidence of occurrences and impacts of glacial and interglacial periods is revealed in three general types of records:**

**(1) Geological glacial surface effects.**

**(2) Analyses of sedimentary rocks, ocean sediments and ice cores.**

**(3) Paleontological fossil distributions.**

**Earth warming and cooling trends are recorded in ice core samples of $CO_2$ which rise when temperatures are warmer and fall during cold periods.**




***Early Climate Changes (Past 150,000 Years)***

**CLIMATE CHANGES** **CLIMATE RECORDS**

**Fossil records reveal important climate change influences upon human evolution:**

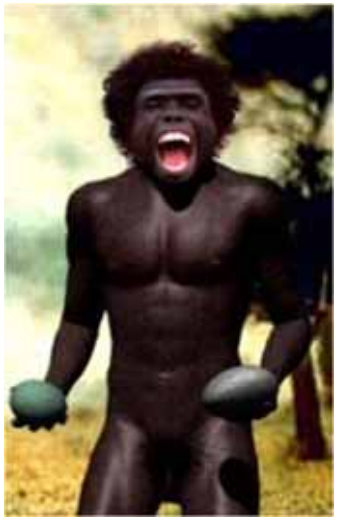
- **About 2.8 million years ago Africa became colder, killing off fruit trees, rain forests, and species that depended upon them, while grassland species thrived.**
- **Around that time, Australopithecus Afranesis ("Lucy") divided into two lineages (genus Paranthorpous and genus Homo).**
- **Another period of colder, drier cycles about 1.7 millions years ago caused Homo Habilius to die out, and a larger-brained Homo Erectus first appeared.**
- **About 1 million years ago when cold, dry periods again became extreme, the genus Parantharopos became extinct, and Homo Erectus migrated from Africa and eventually evolved into modern humans, the Homo Sapiens.**

Content Answers | Archaeology Info | Michigan State Univ.

***Lucy***

***About 2.8 Million Years Ago***

***(First Stone Tools Appeared)***



***Homo Erectus***
***About 1.7 Million Years Ago***

***(More Sophisticated Stone Tools)***

***Homo Sapien***
***About 130,000 Years Ago***

***(Modern Humans Emerged)***

***Influences on Human Evolution***

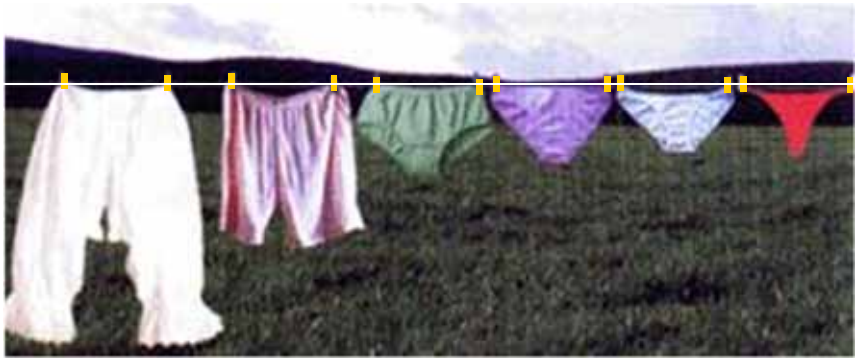
**CLIMATE CHANGES** **CLIMATE RECORDS**

**What about all we hear in the media about agreement among most scientists that global warming, not cooling, is a looming crisis of epic importance?**

**During the 1940s – 1970s there was great alarm because "most scientists" believed the Earth was cooling and rapidly heading towards the next Ice Age.**

**In the mid-1980s temperatures appeared to be gradually rising based primarily upon ground station measurements.**

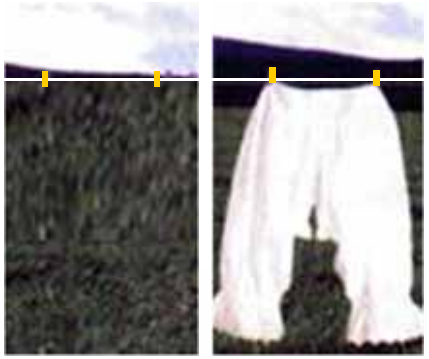
**By the mid-1990s (a decade later) public alarm switched to global warming.**



**18th Century 1900 1950 1970 1990 2000**

***Empirical Evidence of Global Warming***

**Optimistic (?)**



**Pessimistic (?)**

***Climate Trend Projections (2050)***

***Perspectives***

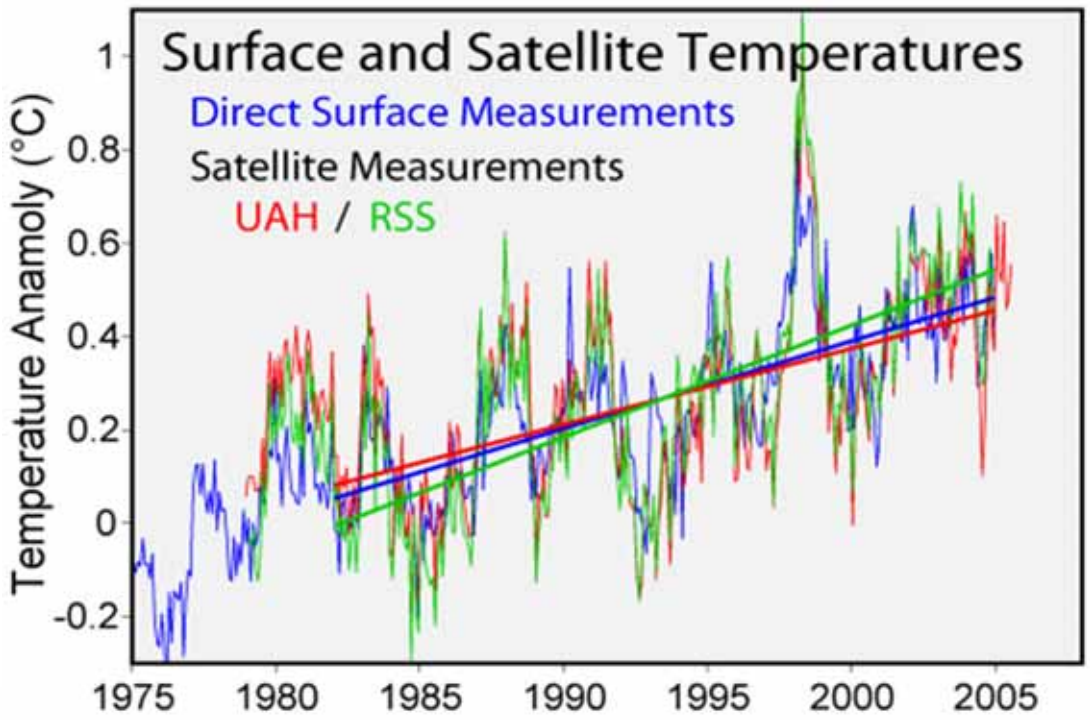
**CLIMATE CHANGES** **CLIMATE RECORDS**

Rober A. Rohde, Global Warming Art

**Observations since the 1980s have recorded slow but steady increases in near-surface temperatures, followed by increases in atmospheric $CO_2$.**

**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.**




***Reconciling Ground and Atmospheric Temperature Data***

**CLIMATE CHANGES** **CLIMATE RECORDS**

**Arguments about how much global warming is actually occurring often center around the types of methods and devices used to measure temperatures.**

**Orbiting satellites provide highly accurate temperature readings, and have recorded data over the past two decades that show little or no increases in global averages.**

**Ground-based thermometers have tended to record warmer temperatures but cover smaller measurement regions.**

| 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***

**CLIMATE CHANGES** **CLIMATE RECORDS**

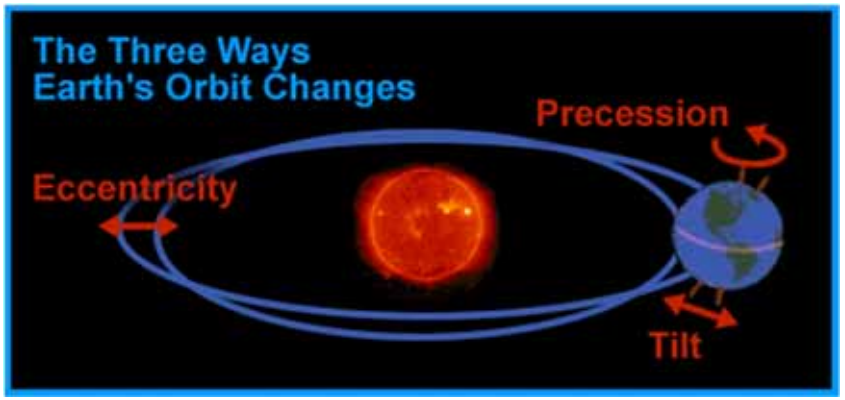
**What is causing these temperature changes? Aren't human activities largely to blame?**

**It is important to look at these changes from a long-term view so that any human contributions can be put into perspective.**

**Observing 100,000-year glacial cycles, changes in Earth's axis "wobble" may be most influential.**

**Earth's elliptical orbit around the Sun may strongly influence interglacial fluctuations.**

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 temperature / climate forcing factors are also linked to changes:**

- **The Sun's thermal output changes over very long and short periods. Solar variability (sunspot activity) generally follows 11-year cycles.**
- **Continental drift causes changes in circulatory patterns of oceans currents, and Ice Ages are most prevalent when a large land mass is positioned at either pole.**
- **Volcanoes and meteor strikes release dust that blocks and reflects sunlight, producing cooling.**

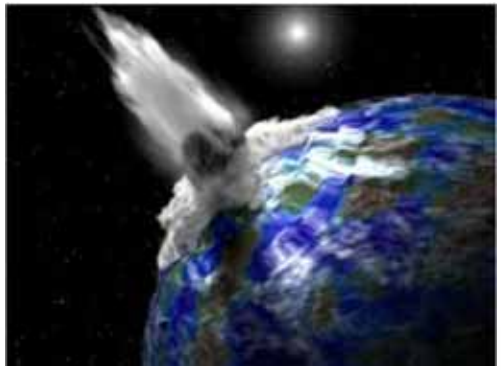
NASA
Isaac Newton Group

*The Sun's output increases about 10% each billion years, and sunspots produce short-term effects.*

NASA
Orbit @ Home

*A continent that is located at the top of a pole (as Antarctica is presently) can block warm water flow to produce cooling effects.*

*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, causing extinctions.*

***Other Potential Influences***

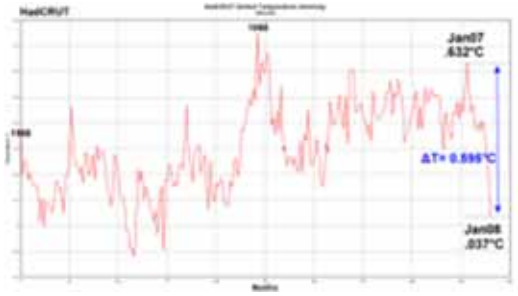
**CLIMATE CHANGES** **FORCING FACTORS**

## Is Earth Beginning to Cool Again?

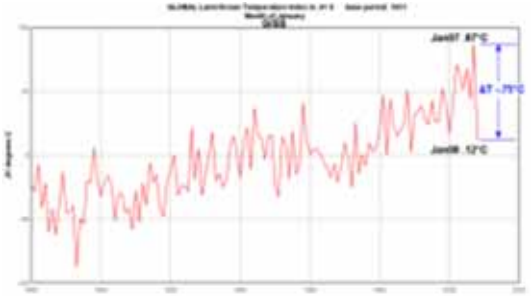
**Most global warming gains during the past 150 years appear to have reversed through observed cooling during the 12 months of 2007 – 2008.**

- **China had the coldest winter in 100 years and Baghdad saw the first snowfall ever recorded.**
- **North America had the most snow in the past 50 years and Wisconsin had the most ever recorded.**
- **Record lows were recorded in Minnesota, Texas, Florida, Mexico, Iran, Greece, S. Africa, Argentina, Chile and Greenland.**
- **Antarctic sea ice expansion was the highest recorded.**

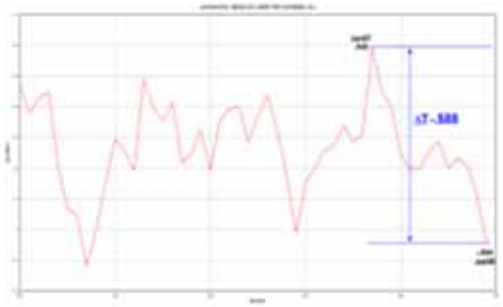
UK's Hadley Climate Research Unit



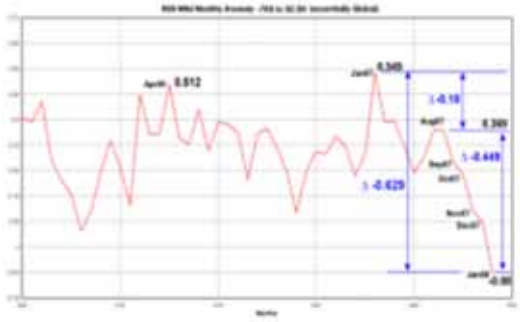

NASA Goddard Inst. For Space Studies



University of Alabama, Huntsville



Remote Sensing Systems of Santa Rosa



Measurements recorded by four major temperature tracking outlets indicate that world temperatures have dropped by about 0.65° C – 0.75 ° C during 2007, the fastest temperature change ever recorded ( either up or down). This 12 month drop approximately equals all reported warming over the past 100 years.

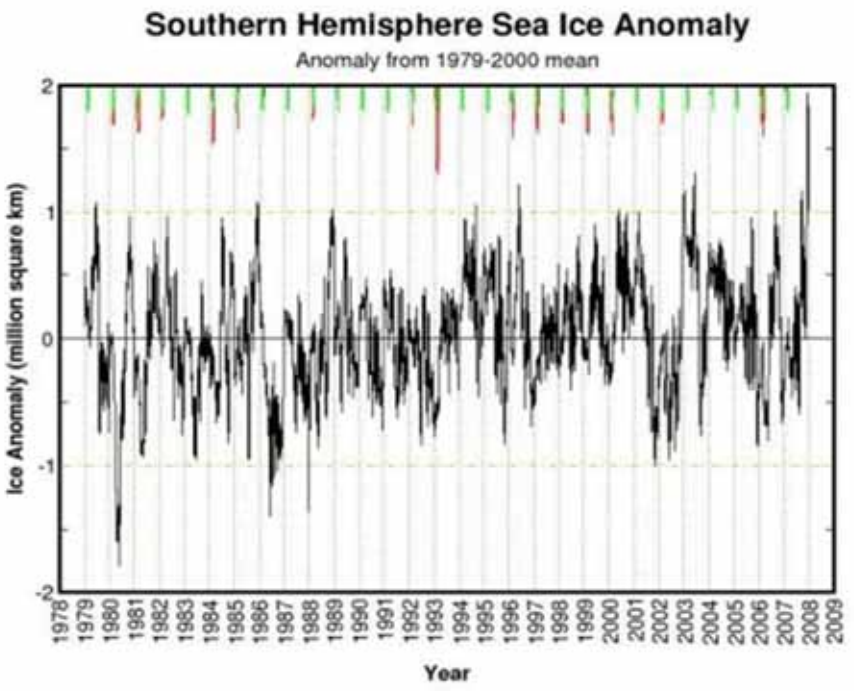
***Dramatic 2008 Temperature Drops***

National Snow and Ice Data Center (NSIDC)

**According to the National Snow and Ice Data Center (NSIDC) at the end of 2007, Southern Hemisphere sea ice expansion was about 1 million square kilometers larger than the 28 year average and 3 million square kilometers above the previous year.**

**During the 20th Century the average global sea level rose only about 1.7 mm/year (about 3 mm/year since 1993).**

**The Antarctic ice sheet is about in equilibrium and represents only about 10 percent of sea level rises.**




Southern Hemisphere Sea Ice Anomaly

By 2008 the Southern Hemisphere ice extent was measured to be about 1 million square kilometers larger than the 28 year average and 3 million square kilometers above 2007.

***Growth in Antarctic Sea Ice***

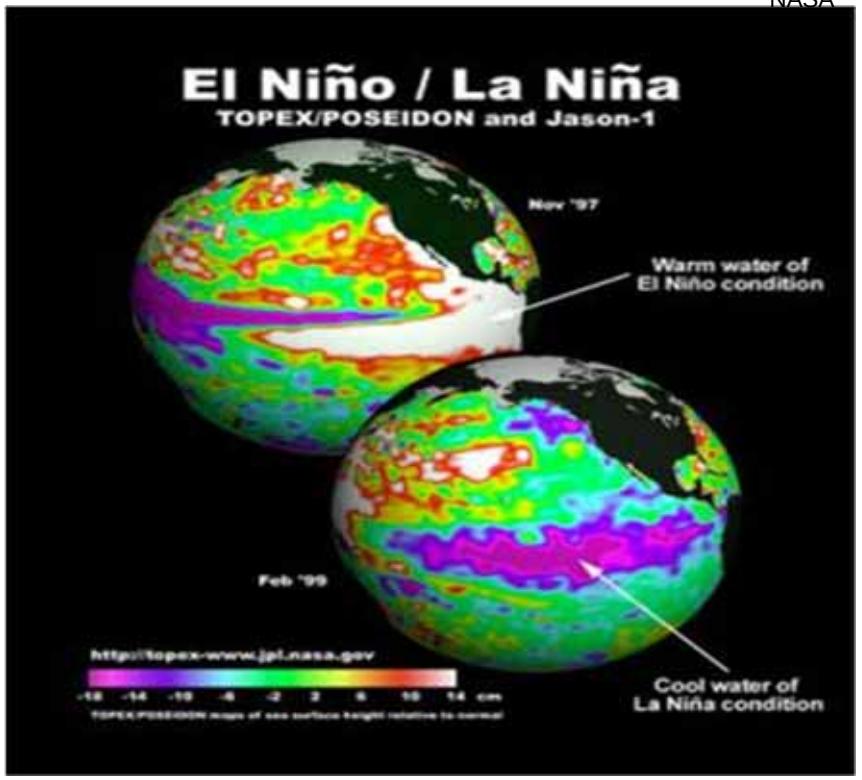
**CLIMATE CHANGES** **RECENT COOLING**

NASA

**Pacific Decadal Oscillation (PDO) and Atlantic Multidecadal Oscillation (AMO) cycles in combination with solar cycles are believed to have important interglacial climate influences.**

**These oscillations are associated with El Nino and La Nina effects on ocean temperature changes.**

**El Ninos produce warmer waters, and La Ninas are cooler.**




El Nino and La Nina conditions in the central equatorial Pacific Ocean as seen by NASA's TOPEX/Poseidon and Jason – 1 satellites. El Nino's warmer waters are indicated in red (1997 image) and La Nina's cooler waters appear as blue (1999 image).

***Ocean Oscillations and Solar Variances***

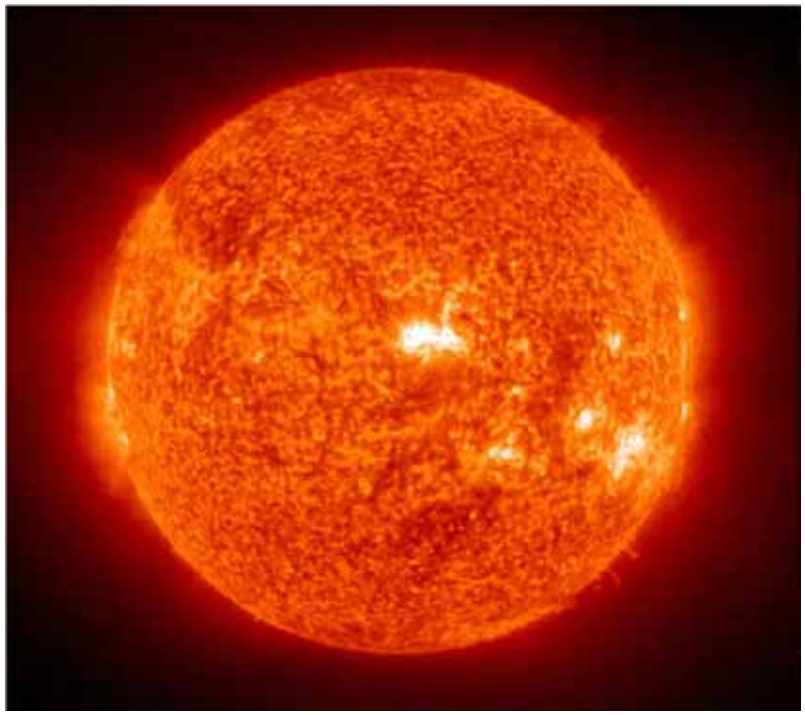
**CLIMATE CHANGES** **FORCING FACTORS**

**Solar activity cycles of about 11 and 200 years appear to correlate closely with global temperature changes:**

**Scientists at the Russian Pulkovo Observatory predict a fairly cold period by 2012, reaching very cold temperatures by 2041 that may last 50-60 years(or longer).**

**The Sun's current 11-year cycle has been very quiet, and may signal the beginning of a new "Maunder Minimum" cold period which occurs every couple of centuries (possibly lasting a century or more).**

NASA



Recent studies indicate that changes in solar activity cycles significantly influence Earth's climate. Solar wind strength modulates effects of Galactic Cosmic Ray (GCR) magnetic fields, producing changes in cloud cover which both warm and cool the surface.

***Solar Activity Cycles***

**CLIMATE CHANGES** **FORCING FACTORS**

**Human activities influence the Earth in a variety of important ways, potentially including significant land use influences.**

**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.**

UCAR
Exec. Action Team

U. of Missouri
Julian Pye

***Land Use Influences***

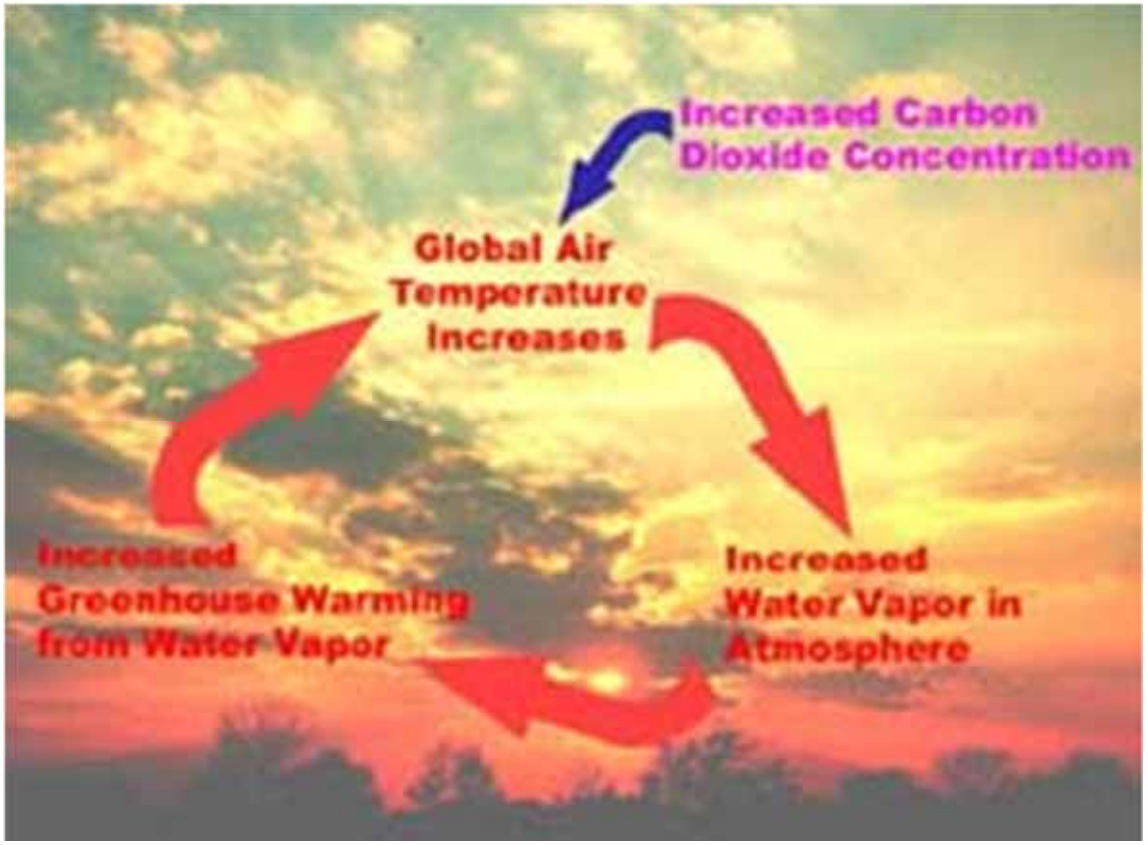
**CLIMATE CHANGES** **FORCING FACTORS**

**But what about $CO_2$ emissions from burning fossil fuels? Isn't this a major forcing factor producing global warming?**

**$CO_2$ may have some influence, but not nearly so much as water vapor (about 36% - 70% for water vapor vs. about 4% - 12% for $CO_2$)**

**As surface temperatures rise, more water from oceans evaporates, adding to atmospheric vapor levels (A "positive water feedback"). NASA satellite data has confirmed this effect, but suggests that the impacts may not be as large as previous climate change models have assumed.**

NASA



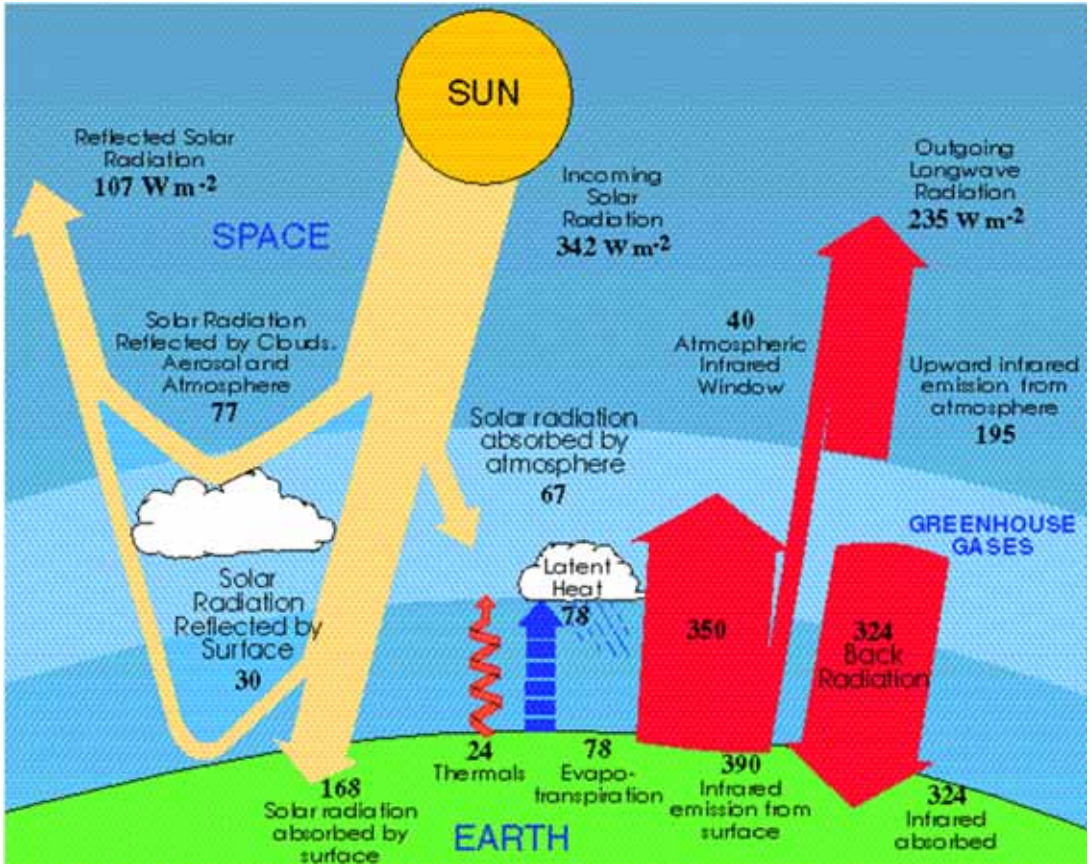

***Greenhouse Gas Feedbacks***

Online Biology Book. Estrella Mountain Community College.

**The Earth's thermal balance is in a steady state of equilibrium when energy stored in the atmosphere and oceans equals the solar energy radiated back into space.**

**Of the total solar radiation that Earth receives, about 70% warms the atmosphere, land, and oceans and powers life.**

**The absorbed incident energy is eventually radiated into space as IR photons, and this amount increases with rising temperatures.**




***Thermal Equilibrium***

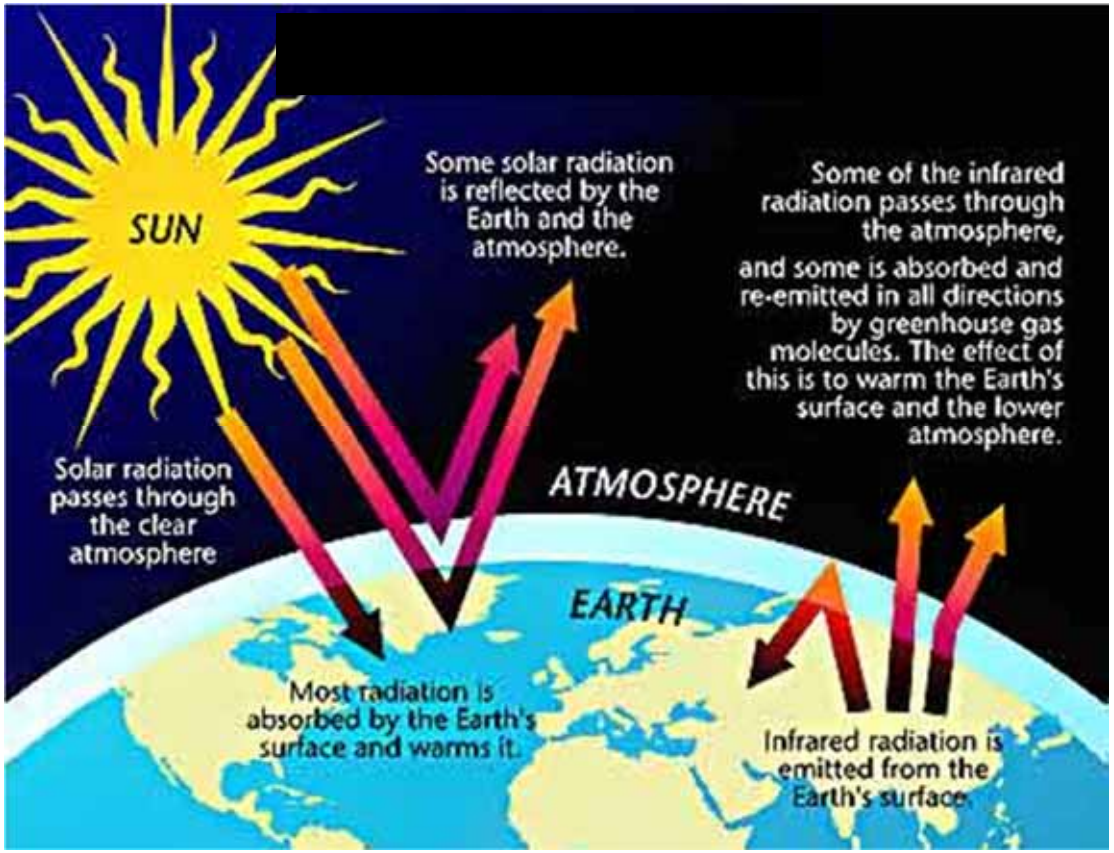
Northern Arizona University.

**Since the atmosphere emits IR both upwards and downwards, these amounts must be balanced to maintain equilibrium.**

**The atmosphere is quite transparent to radiation in the visible range, but strongly absorbs IR wavelengths.**

**This causes most IR photons emitted by the surface to be absorbed by the atmosphere and not escape.**

**Water vapor is a major greenhouse gas that absorbs IR energy.**

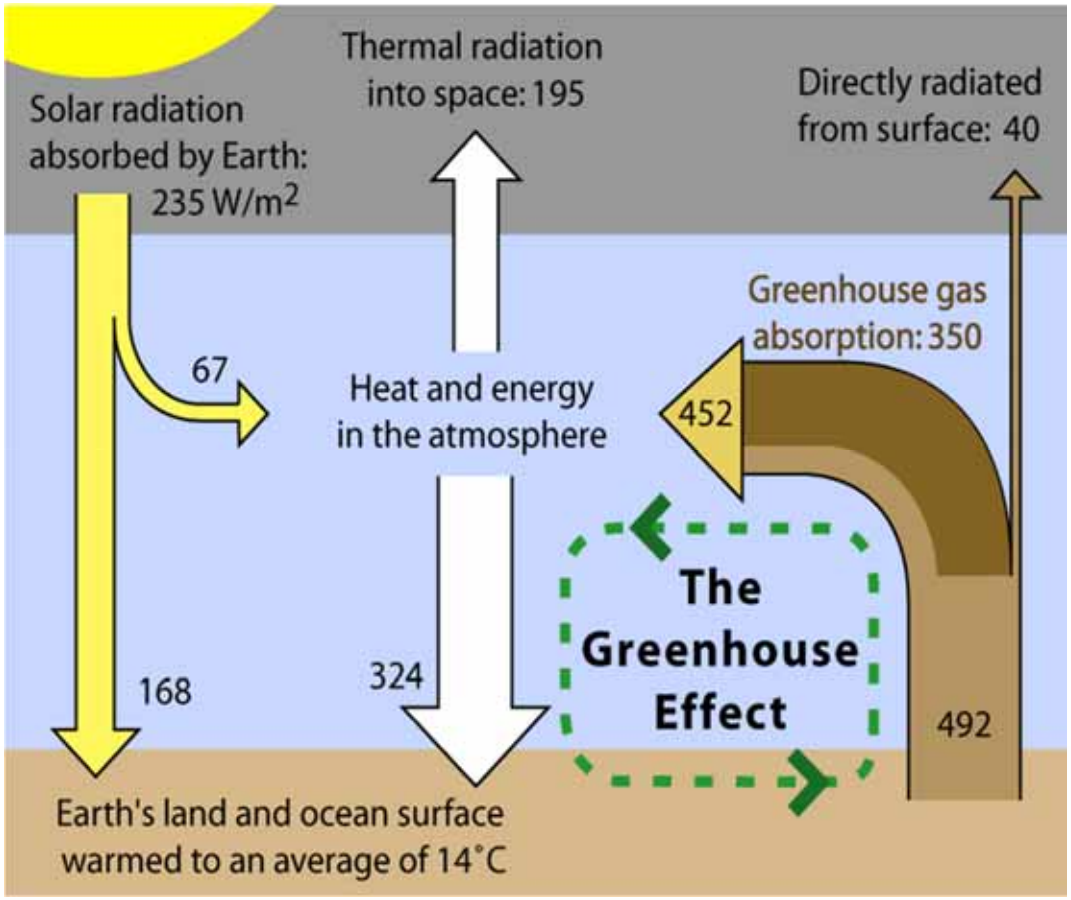



***The "Greenhouse Effect"***

Global Warming Art.

**Clouds are very important IR absorbers, and play increasingly important roles as ocean temperatures rise producing more evaporation.**

**Water vapor and $CO_2$ both absorb IR, although $CO_2$ is much less influential, followed by ozone constituting very tiny amounts of the atmosphere.**



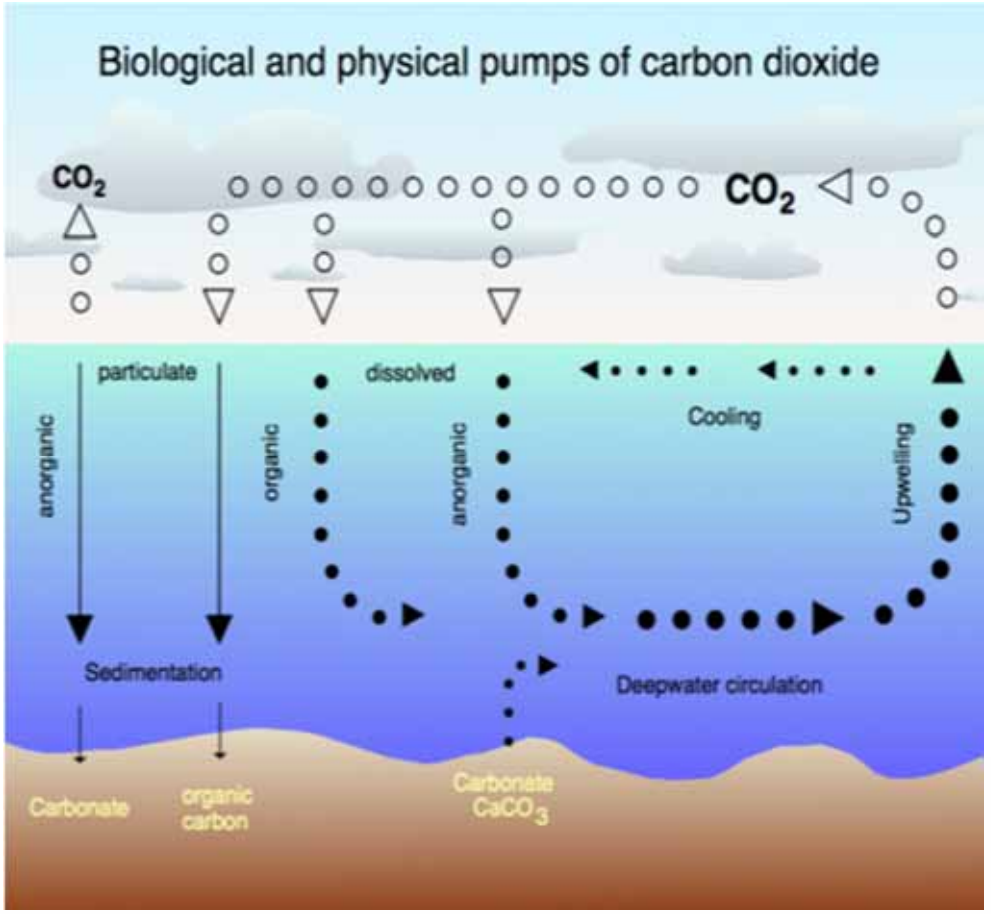

***Greenhouse Mechanisms***

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

**Most atmospheric $CO_2$ (about 97%) comes from natural sources, particularly circulation of ocean calcium carbonate and respiration of living organisms and micro-organisms.**

**Polar ice core records show that atmospheric $CO_2$ concentrations have fluctuated greatly over Earth's history, reaching levels much higher than those during recent times.**

**$CO_2$ also fluctuate greatly on a seasonal basis as a result of plant growth cycles and warming / cooling changes that influence ocean absorption rates.**



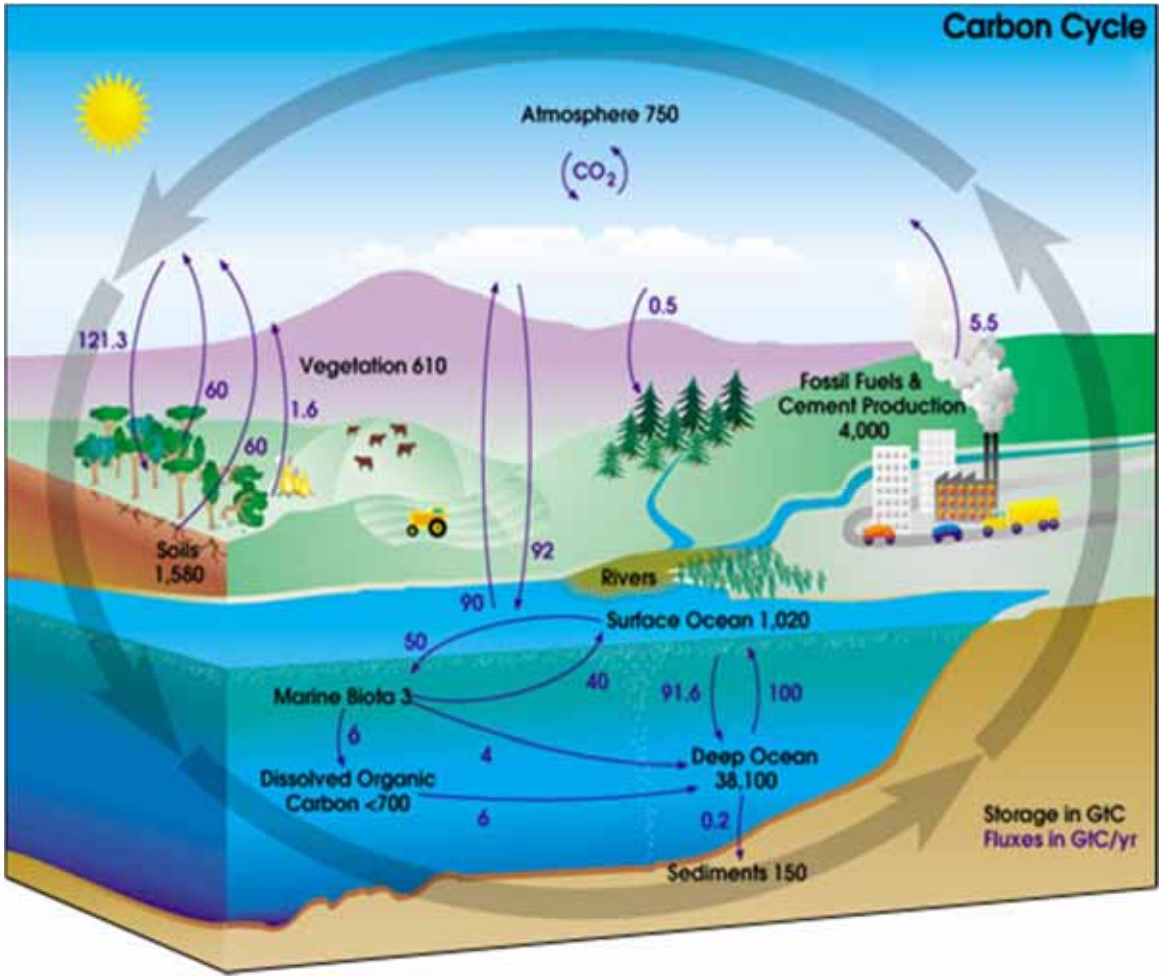

***$CO_2$ from Ocean Carbonate***

NASA

**Carbon, typically in the form of $CO_2$, naturally cycles between "reservoirs" in the atmosphere, oceans, and land.**

**Carbon (mostly $CO_2$) only constitutes about 0.4% of the atmosphere on a molecular basis.**

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




***Atmospheric Carbon Cycle***

**CLIMATE CHANGES**

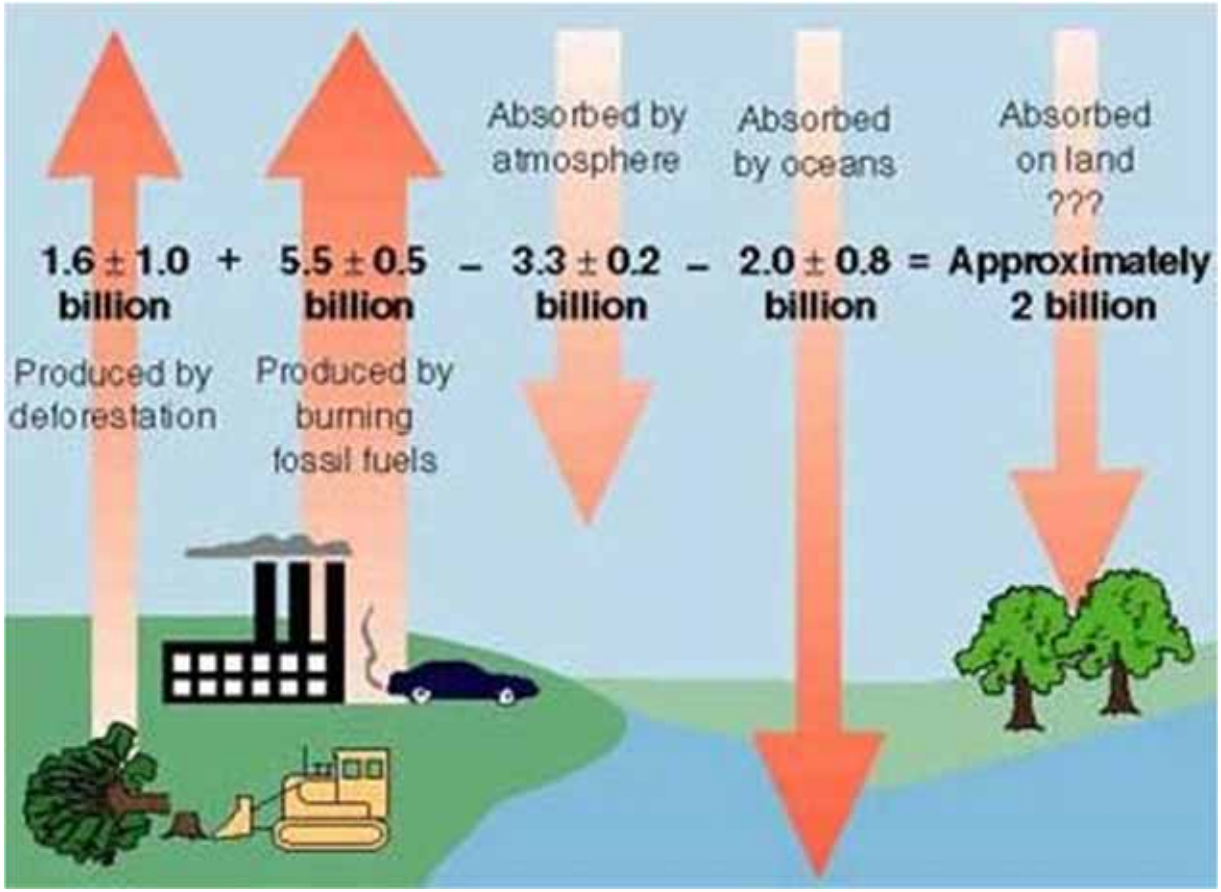
**$CO_2$ SOURCES AND INFLUENCES**

US Geological Survey

**Although $CO_2$ represents only a very tiny amount of total atmosphere gas content, levels have been observed to increase from about 110 ppm to about 360-380 ppm since the Industrial Revolution.**

**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.**




***Estimated Human Contributions***

**CLIMATE CHANGES**

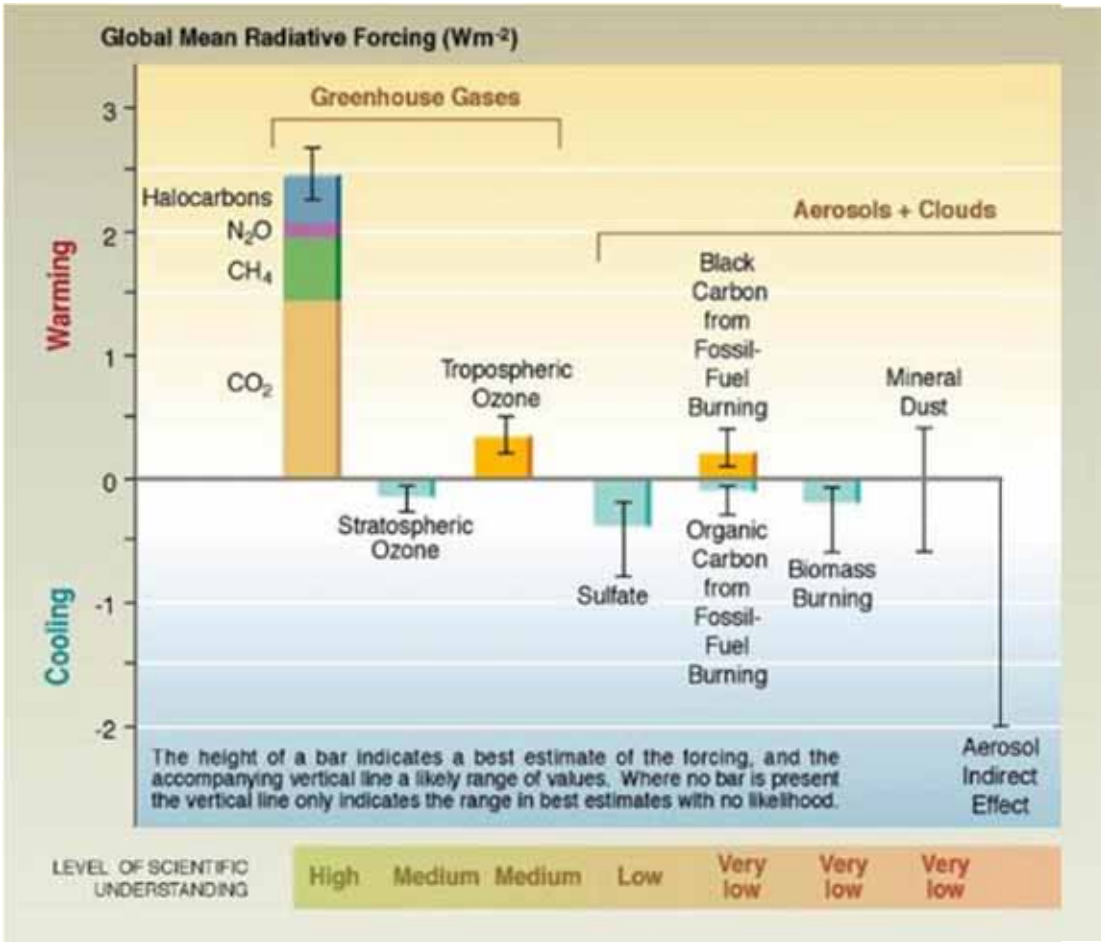
**$CO_2$ SOURCES AND INFLUENCES**

**Aerosols released from a variety of natural and human sources 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.**

**High levels of uncertainty remain regarding atmospheric concentrations of aerosols and greenhouse gases from human vs. natural sources and overall climate impacts.**



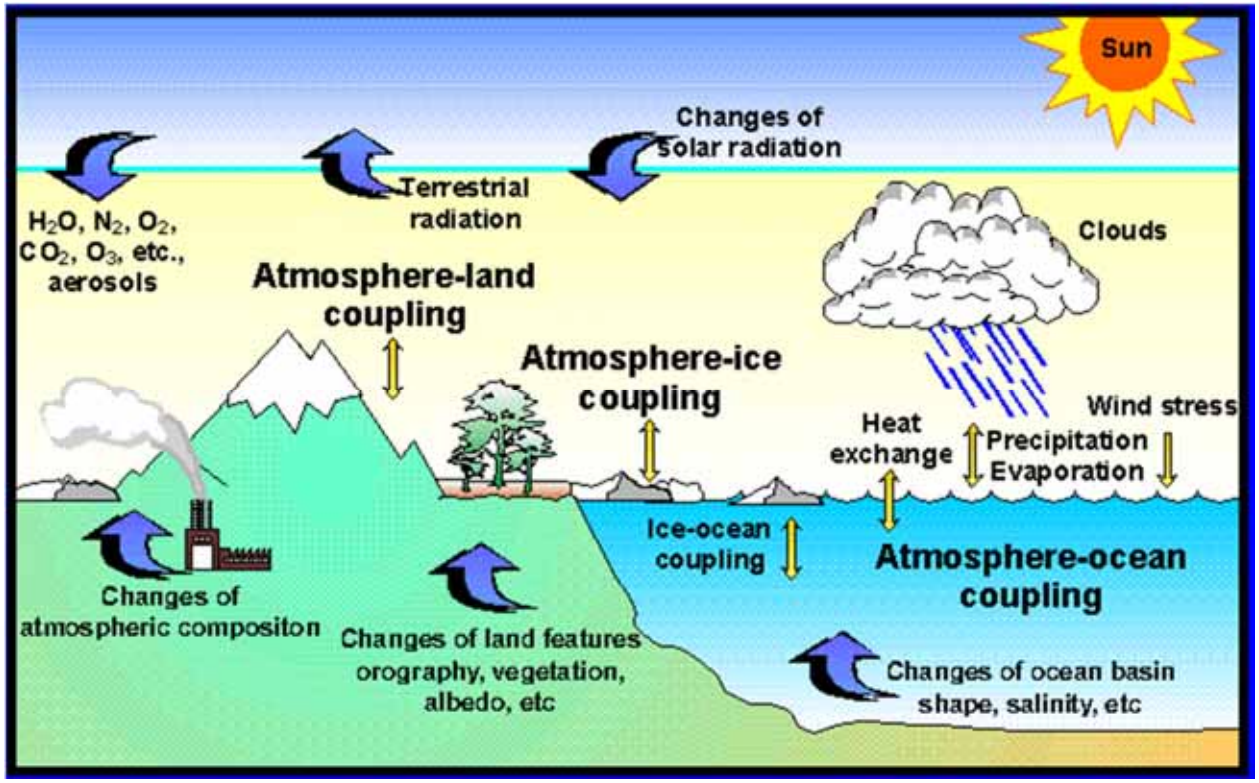

***Estimated Aerosol / Greenhouse Influences***

**CLIMATE CHANGES** **MODELING CHALLENGES**

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.**



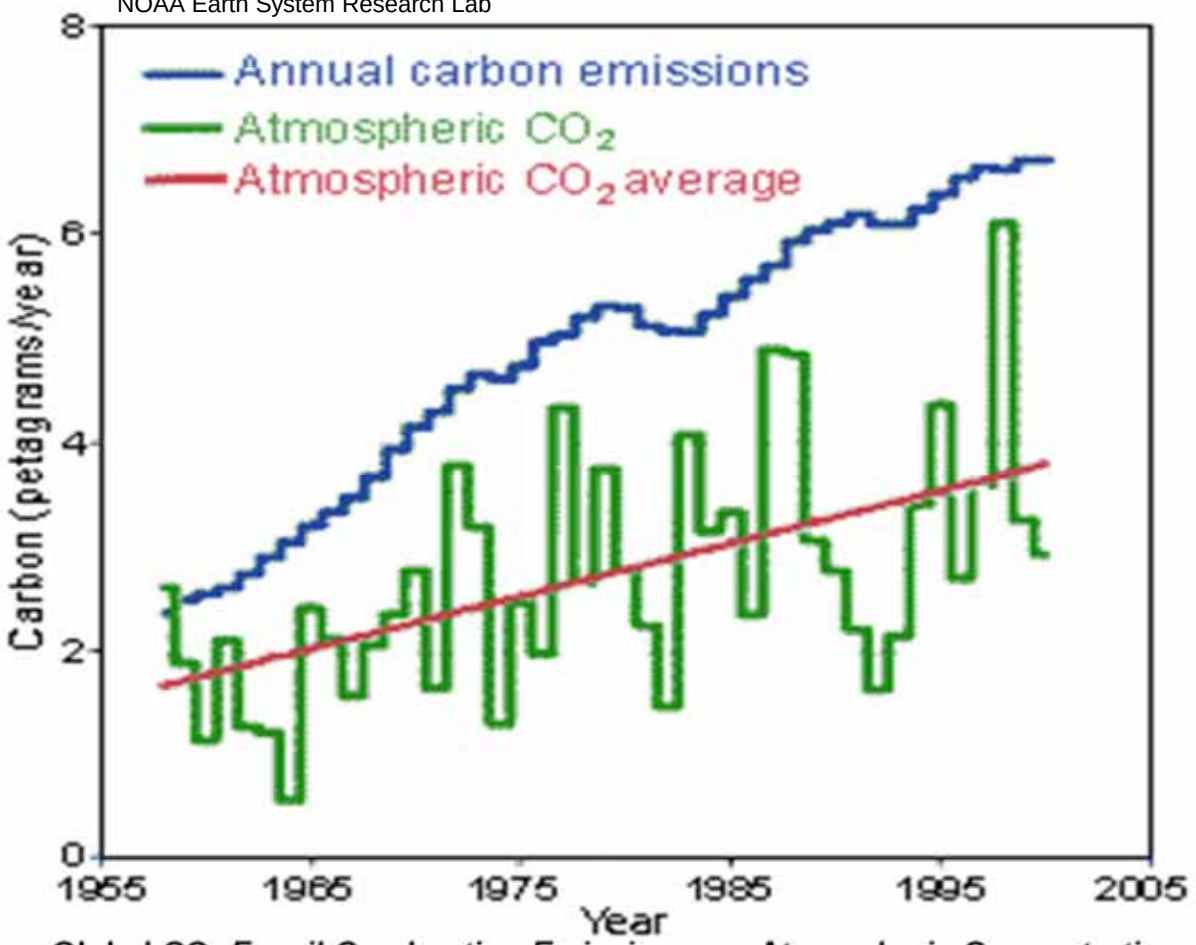

***Interactive Influences***

**Recognizing that climate models are imperfect and unreliable, why assume that the human impacts are unimportant, particularly with regard to carbon dioxide emissions?**

**We shouldn't. Yet at the same time it is important to recognize that human contributions to atmospheric $CO_2$ levels are small, and that they do not accumulate in a linear manner.**

**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.**

NOAA Earth System Research Lab



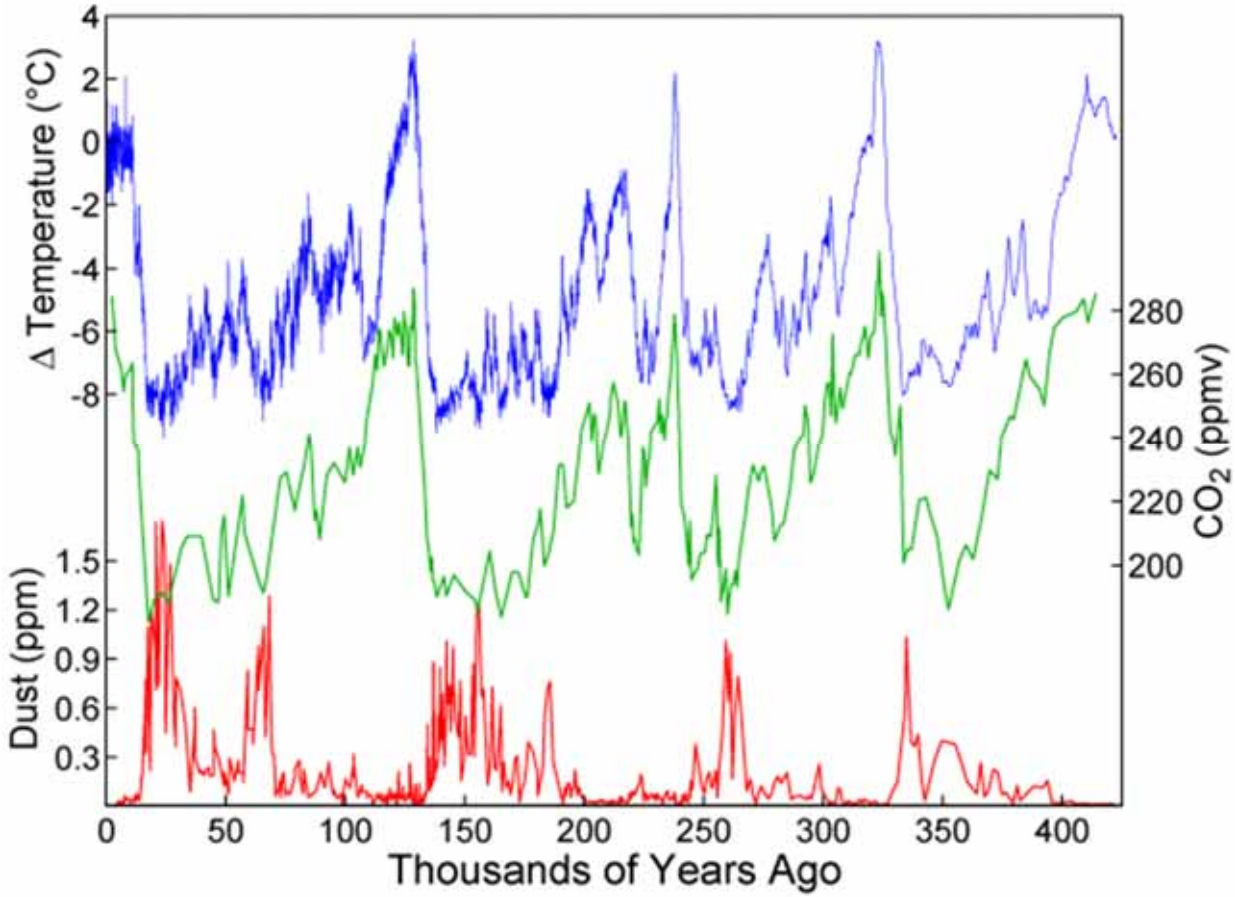

***Global $CO_2$ Fossil Combustion Emissions vs. Atmospheric Concentrations (billions of tons of carbon / year)***

**It is also important to consider that $CO_2$ levels greatly fluctuate over long time periods following (not leading) temperature changes that preceded possible human influences.**

**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.**

Petit et al. Nature, 1999




***Correlations with Atmospheric Dust and $CO_2$ Levels***

**CLIMATE CHANGES** **CAUSES AND EFFECTS**

**How can we account for dramatic weather events such as the devastating hurricane seasons of 2004 and 2005 if not for global warming climate change?**

**Interglacial periods are characterized by dramatic climate shifts which include temperature and atmospheric circulation changes.**

**Hurricanes are intense low-pressure areas that form over warm oceans in the summer and early fall driven by evaporated water vapor that releases heat energy and condenses to form clouds.**

**Tropical thunderstorms and wind shears are produced that create even more evaporation and turbulence.**

**Connections to global warming are currently unclear.**

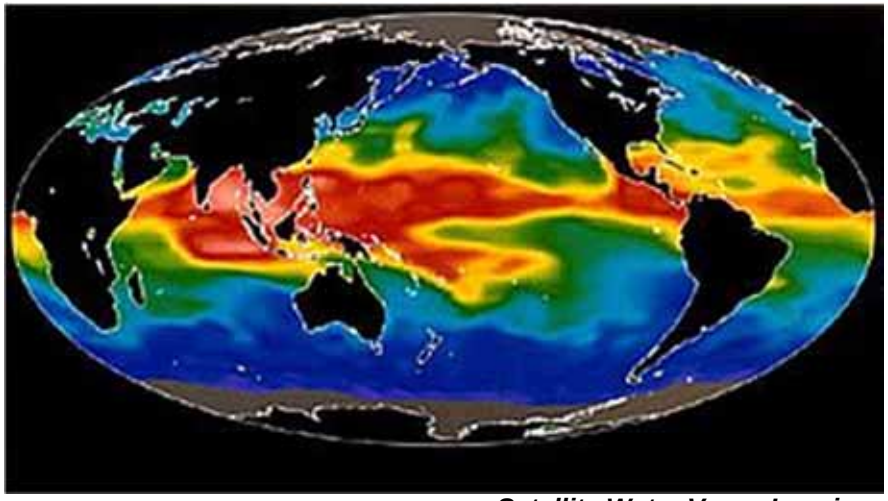
NOAA

***Hurricanes***

**Since water is the primary greenhouse gas and atmospheric concentrations would be expected to increase through evaporation due to global warming, this effect has not yet been observed.**

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

NASA Goddard



***Satellite Water Vapor Imaging***

*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.*

***Water Vapor Measurements***

| 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 / $CO_2$?***

**CLIMATE CHANGES** **GLOBAL WARMING CONCERNS**

**Intelligent, highly-educated and extremely dedicated people hold different opinions about causes and impacts of climate changes.**

**The passions surrounding these debates reflect the enormous importance attached to their concerns, and deserve appreciation.**

**Progress demands that theories be regarded as unproven possibilities, and "established facts" be constantly tested based upon new information and better models.**

**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?

***Important Climate Questions***

**CLIMATE CHANGES** **GLOBAL WARMING CONCERNS**

**What about daily media reports insisting that most scientists regard global warming to be a serious threat, and human $CO_2$ to be a leading cause, evidenced by the Kyoto Protocol, aren't these internationally accepted viewpoints?**

**Serious consideration of this matter should take historical / scientific and political / economic factors into account:**

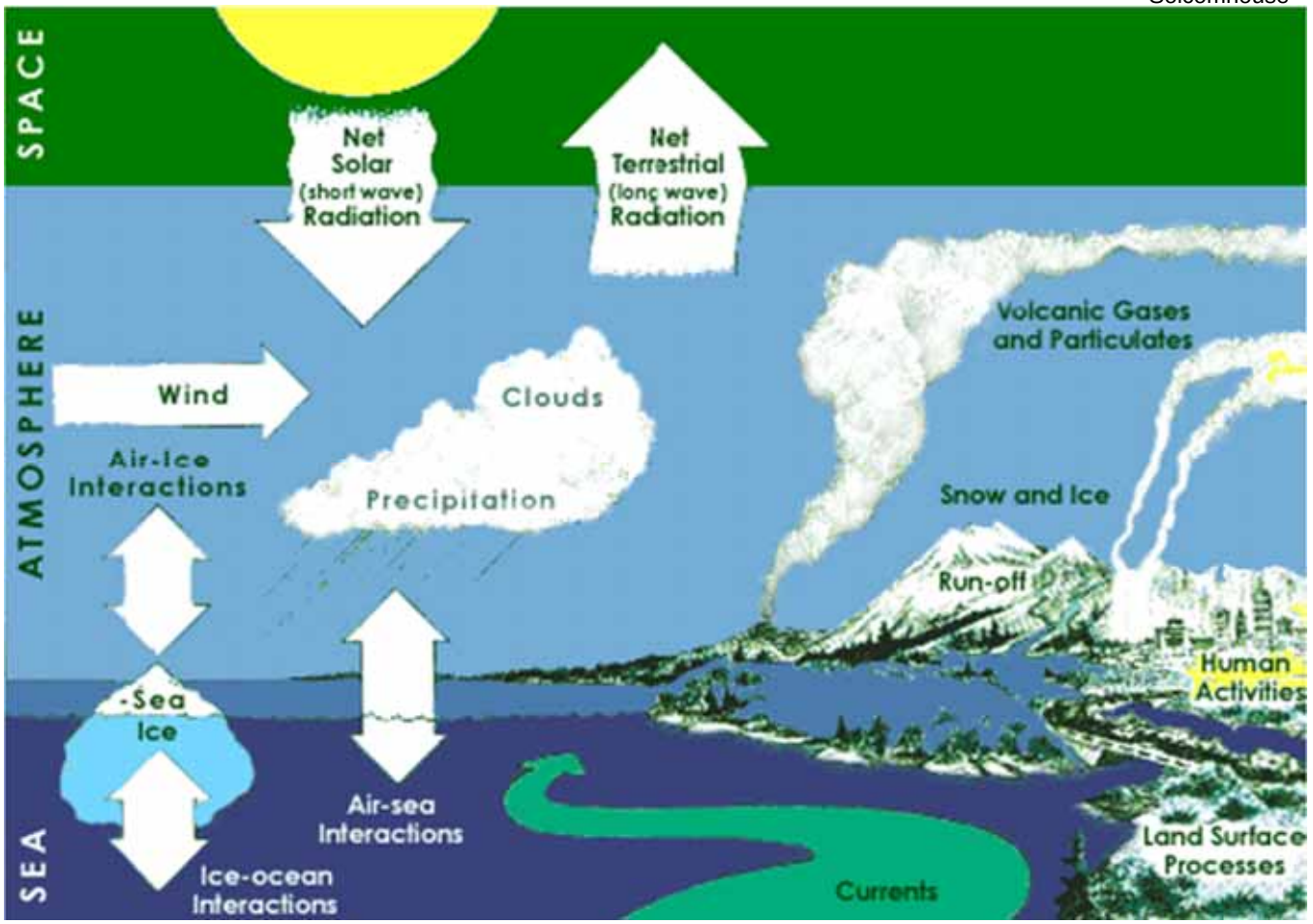
- **In 1989 as the Cold War threat was winding down, the Union of Concerned Scientists circulated a petition citing great dangers of global warming signed by 700 scientists (of which only 4 were climatologists).**
- **A UN International Panel on Climate Change (IPCC) established in that time frame agreed and cited human $CO_2$ as a major cause.**

Xinhau


***The $CO_2$ Controversy***

**The IPCC concluded that "*all global warming scenarios ultimately lead to sea level increases*" (based upon data available at that time).**

**Yet they also recognize that 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. Potential cloud influences were emphasized.**




***Kyoto Climate Model Uncertainties***

**The Kyoto Protocol became active in 2005 after ratification by Russia following an offer by Europe to invite them into the World Trade Organization:**

- **Strongly advocated by the EU, the Protocol required participating industrialized nations to reduce $CO_2$ and five other GHGs by 5.2% under 1990 levels between 2008-2012, and allowed dirty carbon credit trading among EU and former Soviet countries (but not the US).**
- **China and India were exempted from GHG restrictions.**

CNN


*The US and Australia have declined ratification of the Kyoto Protocol. Russia agreed to ratify following an offer by Europe to join the World Trade Organization (WTO).*

***Kyoto Protocol Positions***

**The US continues to believe that the Kyoto Protocol terms offer enormous advantages to the EU and Russia due to previously very high pollution conditions in those regions during the 1990.**

**The US also takes strong exceptions to exemptions for China and India.**

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

Planetsave

***China Protocol Exemptions***

| 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***


*The Byrd-Hagel Senate Resolution 98 Vetoed Kyoto Protocol Terms*

**Neither the Clinton or Bush Administrations have submitted the Kyoto Protocol for Senate ratification which was unanimously rejected in principle by a 95-0 bi-partisan vote on the Byrd-Hagel Senate Resolution in 1998.**

**Although Vice President Al Gore symbolically the signed the Protocol, it was never submitted to the Senate where it would obviously be "dead on arrival".**


*Neither the Clinton nor Bush Administrations Sought Kyoto Senate Ratification*

***Bi-Partisan Kyoto Rejection***

**US objections to the Kyoto Protocol were also based upon economic and environmental grounds:**

- **The 2008 compliance schedule was regarded to be unrealistic due to technology transition time requirements.**
- **Some environmentalists argued that carbon credits for forest planting would provide incentives to destroy wetlands.**
- **Some climatologists believe that any real $CO_2$ reductions would be trivial and difficult / impossible to measure.**

***Technology Phase-Out Schedule***

***Destruction of Wetlands***

***Economic and Environmental Issues***

**Little real progress has occurred since the Protocol was brought into force:**

- **Europe and Japan are struggling to meet their GHG targets, and Canada has given up entirely.**
- **Germany has exempted its coal industry from compliance, and France (80% nuclear) is building the world's largest nuclear plant in Finland.**
- **China and India enjoy explosive industrial and economic growth, along with pollution, unaffected by the Protocol.**
- **Al Gore continues to criticize US policies towards the protocol, sermonize about the certainty of $CO_2$ dangers, and promote carbon trading.**

***"It ain't what you don't know that gets you into trouble, it's what you know for sure that just ain't so."***
*(Al Gore quoting Mark Twain)*

***Protocol Results***

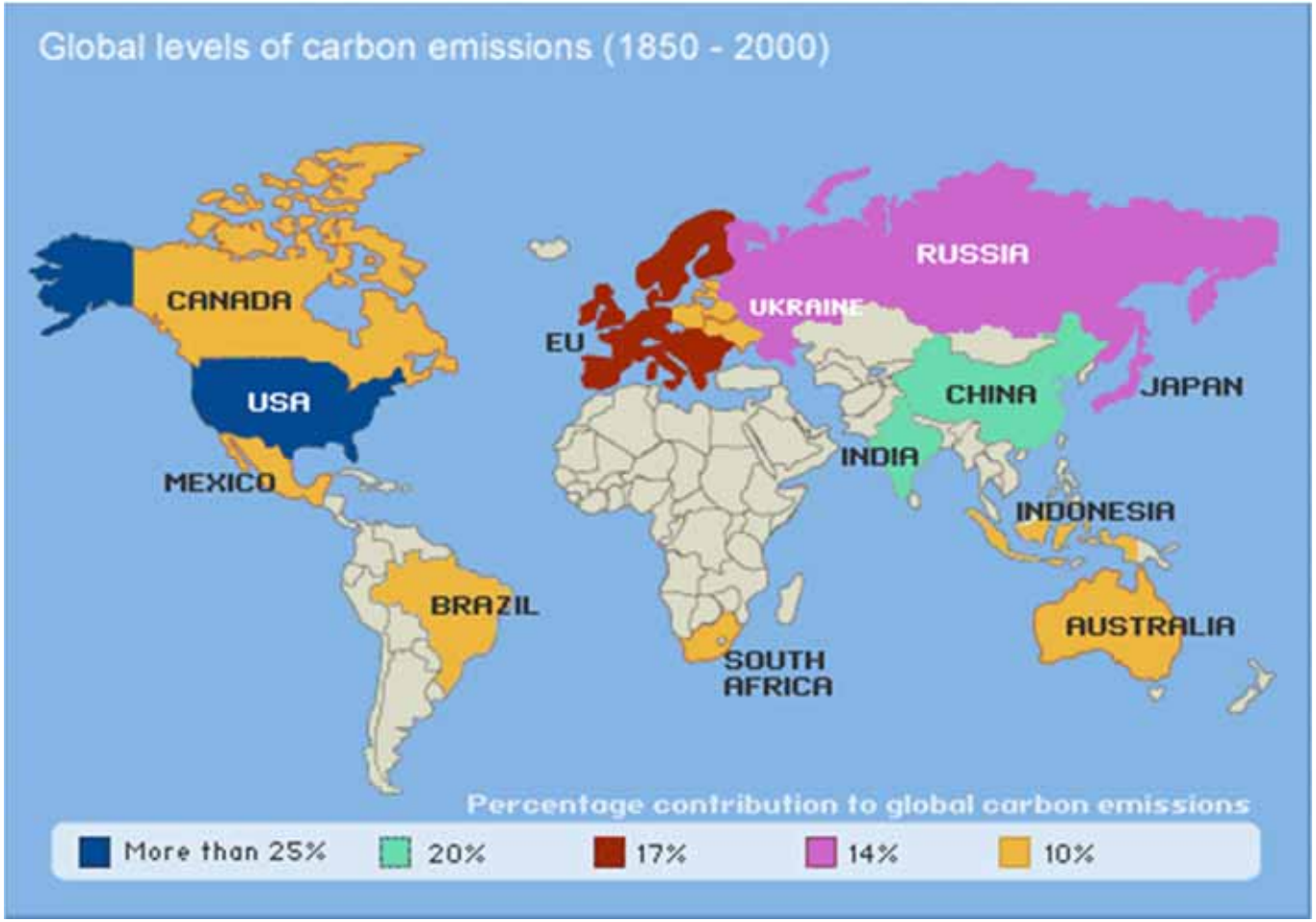
**Do economic considerations have a legitimate place in subjects so urgent as world climate and pollution?**

**Consider that:**

- **A healthy economy is essential to support families of all income levels, finance education and public services, and create safe and affordable energy and food.**
- **Businesses / Industries that are forced to relocate to countries with lower environmental standards compound economic stress with global pollution impacts.**
- **Economic prosperity reinvested by industry provides cleaner, more efficient production and products.**

- **Establish a responsible balance between state/regional/national economic and environmental interests by ensuring that both priorities are fully and effectively represented in policy and finance decisions.**
- **Provide business incentives and regulatory mechanisms that promote clean industries without imposing overly burdensome costs and restrictions that send production and jobs overseas to places that are cheaper in part due to lack of equivalent standards.**
- **Protect national economic 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.**

**Several countries that have ratified the Kyoto Protocol, including China, India, Japan, and South Korea, have joined with the US and Australia in agreeing to voluntary GHG reduction goals. Canada is also likely to participate.**



**It is important to realize that cyclical and unpredicted climate changes are a natural reality that can occur rapidly with significant consequences:**

**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 continued survival will depend upon learning how to protect the planet from our impacts, probably the greatest adaptation challenge of all.**

ChemistryLand

NASA

***Adapting to Changes***

**CLIMATE CHANGES** **MOVING FORWARD**

NOAA / NASA

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

**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*."**

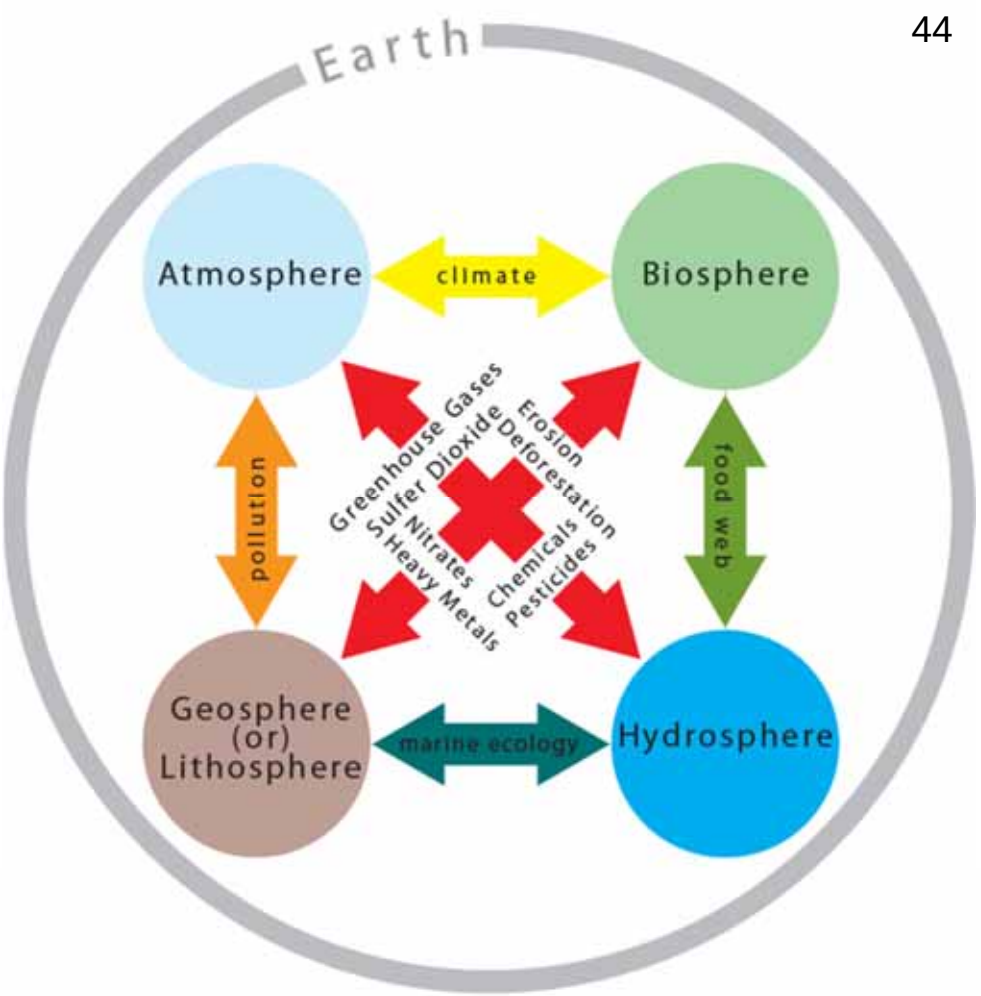
***New Tools and Understanding***

**Knowledge about changes we are imposing upon our planet enables us to adapt our living habits, industries and technologies to prevent unfortunate and avoidable events such as resource exhaustion, ecosystem destruction and climate changes:**

- **Rapid changes, over relatively short periods can be more hazardous and disruptive than slow ones, with less time to adapt.**
- **Unlike our early ancestors, we won't be able to simply pack up and relocate large populations to more favorable areas, particularly across restricted national borders.**

**In addition to advancements in information and technology, we enjoy 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:**

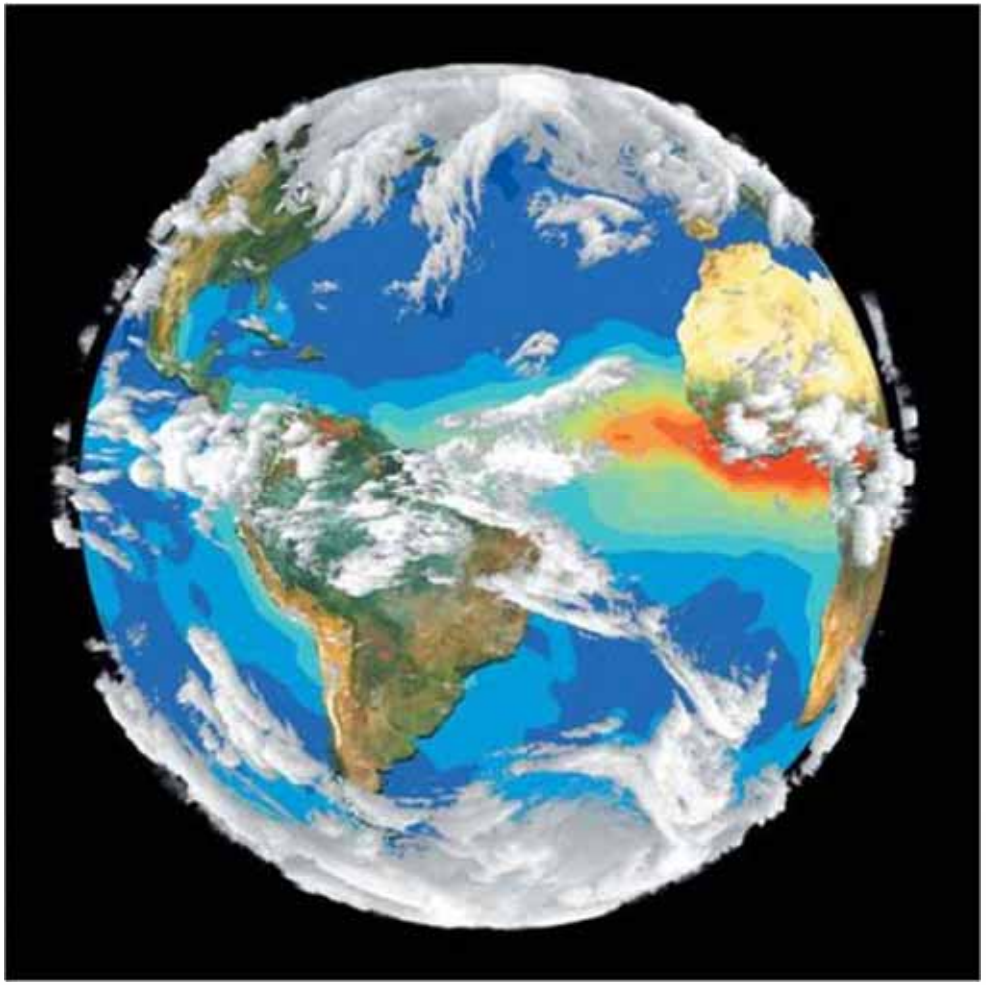
- **As students of Nature and Earth's history we learn that very large events and consequences can precipitate from small compounding influences.**
- **We can also readily observe that human influences upon this plant's fragile lands, oceans and atmosphere are pervasive and unsustainable.**




***Human Contributions to Global Change***

**CLIMATE CHANGES** **MOVING FORWARD**

NASA



**There is no escape from a reality that we are all members of a global civilization, nor from the impacts that our common community create 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:**

**This image was 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.**

**We must change the ways we treat our natural environment before it retaliates in ways we cannot correct.**

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

***Our Legacy***