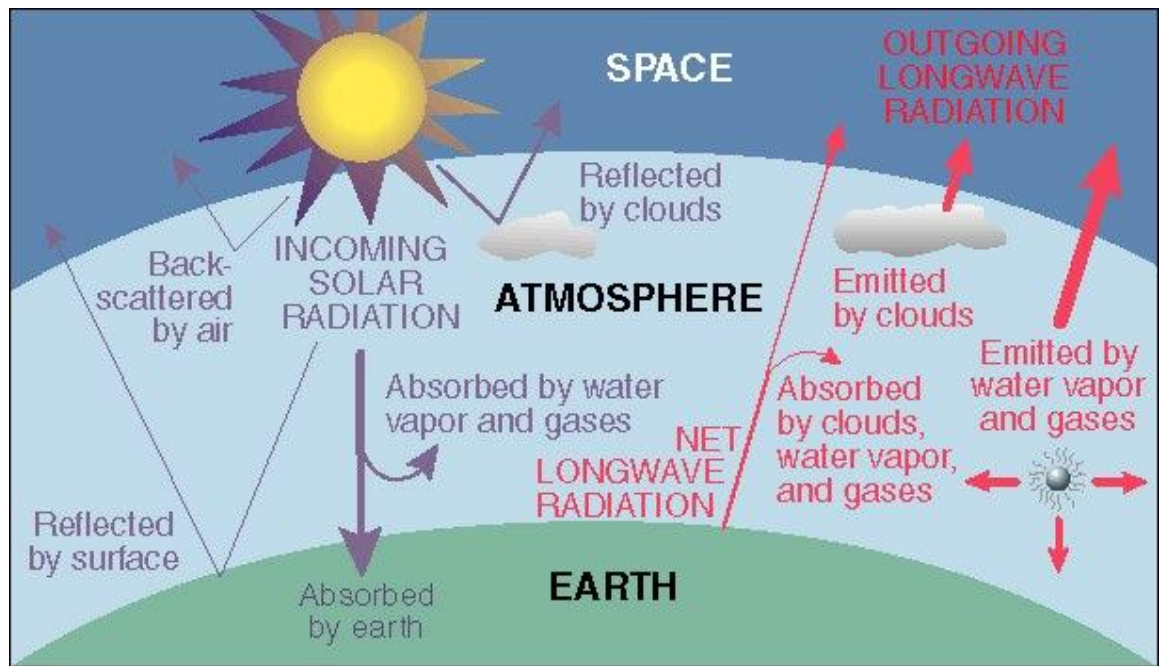
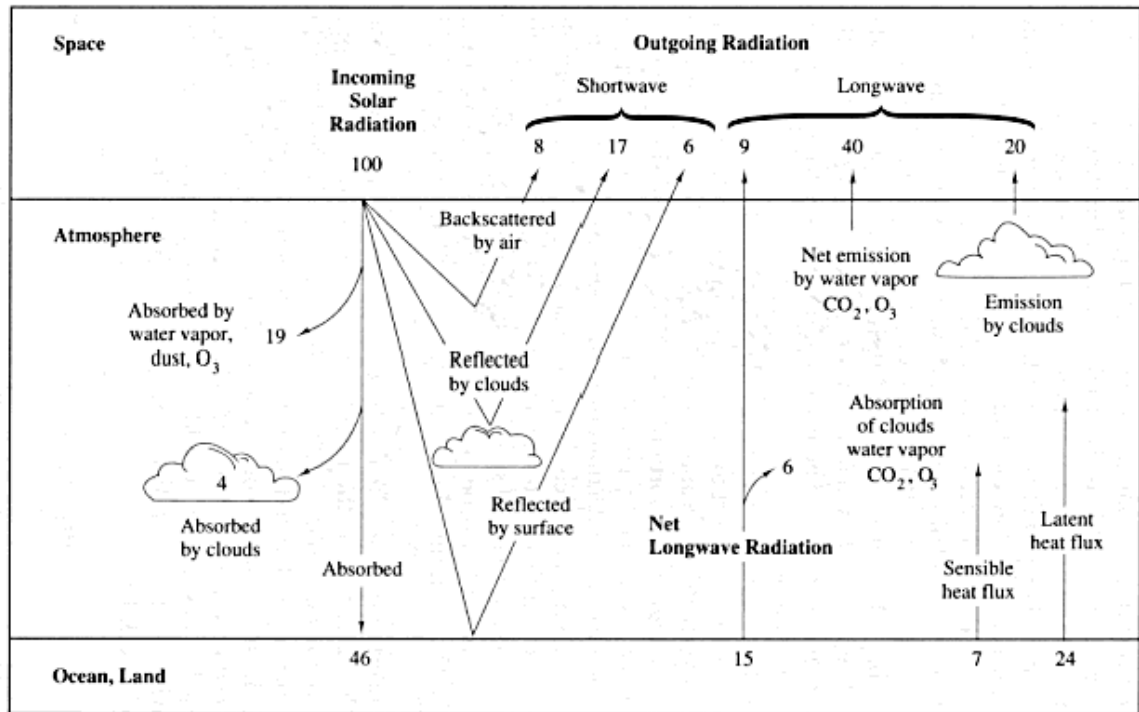


How does it happen?



Climate change refers to any significant change in measures of climate (such as temperature, precipitation, or wind) lasting for an extended period (decades or longer).



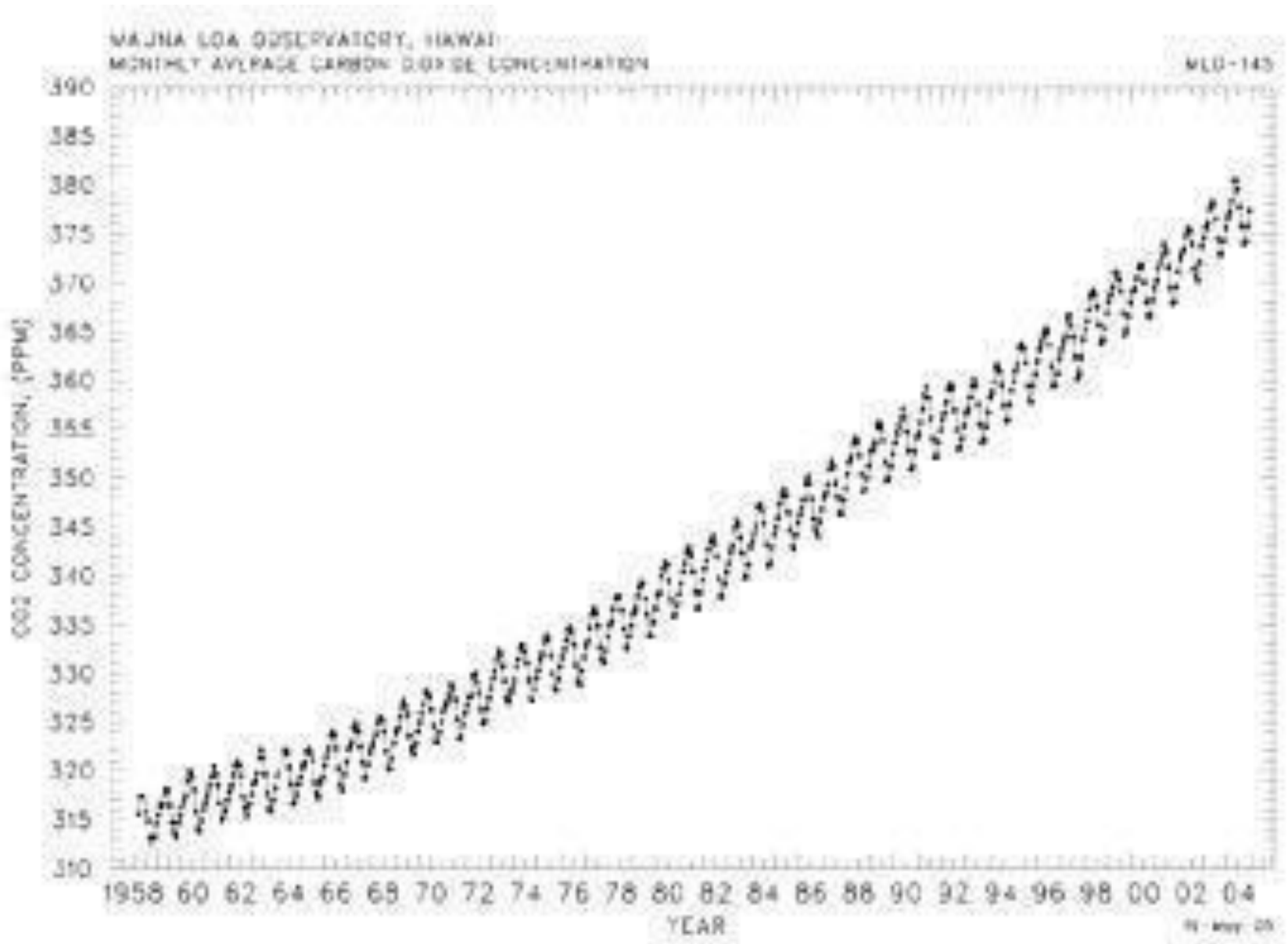


Objectives:

- *Article by former climate denier.
- * SWBAT list and explain the different greenhouse gases and their warming potential.

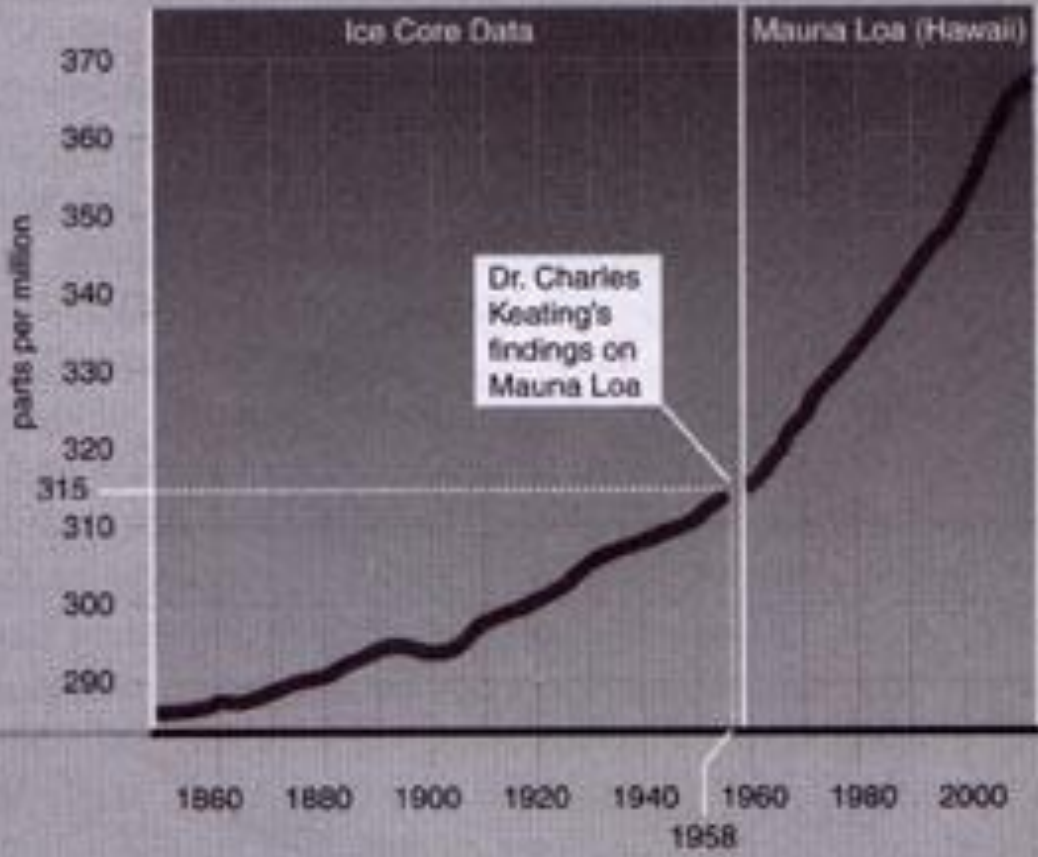
Warm Up:

What are the main causes of climate change?



Keeling curve

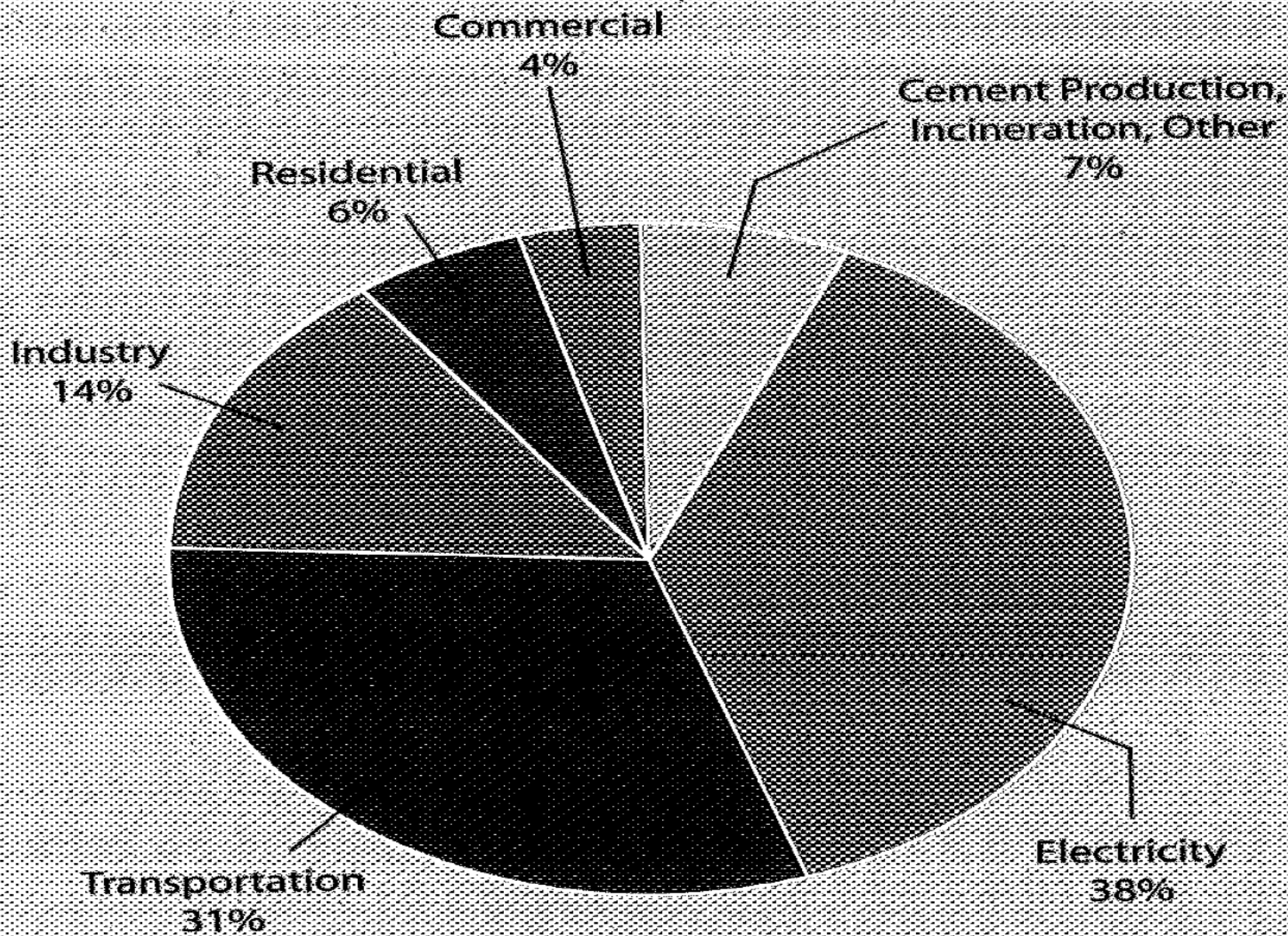
Carbon Dioxide Concentrations in Earth's Atmosphere



Ancient ice from Antarctica was tested by scientists who found that carbon dioxide levels had been about 280ppm in the 1700s (before the Industrial Revolution).

In 1958 after taking a series of readings, Dr Keeling determined that carbon dioxide levels was 315 parts per million (ppm) and in 2000 the CO2 level was 367ppm. 2006 level 381 ppm = 36% increase over pre-industrial levels.

million metric tons



Taken from “Earth the operator’s manual” by Richard B. Alley.

Carbon dioxide levels stood at 280 ppm before serious fossil fuel burning. We have raised it past 390 ppm.

Small numbers right?

The U.S. center for disease Control & Prevention recommends that we limit occupational exposure to carbon monoxide to less than 35 ppm.

For hydrogen cyanide gas just 135 ppm with be fatal is 30 minutes.

There are many examples where a trace of something makes no difference, and other examples in which a trace is highly dangerous.

This is why scientists are hired to study these things – we need hard data & real understanding, not vague guesses about how much is too much.

The hard science says that the trace of Carbon dioxide up there is important to our climate, and that changing the CO₂ concentration will change the climate.



CARBON DIOXIDE (CO₂)



METHANE (CH₄)



BLACK CARBON IN GAS



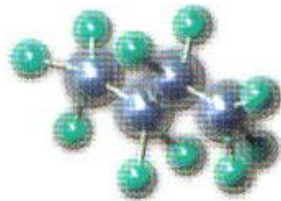
SULFUR HEXAFLUORIDE (SF₆)



TETRAFLUOROETHANE
(CH₂FCF₃)



CARBON MONOXIDE (CO)



BUTANE (CH₃CH₂CH₂CH₃)



NITROUS OXIDE (N₂O)

A GUIDE TO GLOBAL WARMING POLLUTANTS

All global warming comes directly or indirectly from the effects of six families of pollutants (see “The Sources of Global Warming,” right). The largest role is played by carbon dioxide (CO₂), the most abundant and most rapidly increasing greenhouse gas. Methane (CH₄), also a greenhouse gas, is the second worst cause, followed by black carbon (soot). Important roles are also played by industrial chemicals invented in the 20th century—chlorofluorocarbons; halocarbons, such as tetrafluoroethane (CH₂FCF₃); and sulfur hexafluoride (SF₆). All of these chemicals trap heat in the atmosphere. Carbon monoxide (CO) and volatile organic compounds (VOCs)—such as butane—do not trap heat directly but interact with other pollutants to create compounds that do trap heat. Finally, nitrous oxide (N₂O)—which is mainly a by-product of nitrogen-intensive agriculture—plays a smaller but still significant role in trapping heat in the earth’s atmosphere.

Effects of Different Greenhouse Gases

	CO ₂	CH ₄	N ₂ O	SF ₆	CF ₄
Global Warming Potential (GWP)	1	21	310	23,900	6,500
Atmospheric Lifetime (years)	50-200	9-15	114	3,200	>50,000
Pre-industrial Concentration (ppm)	280	0.722	0.270	0	40
2001 Atmospheric Concentration (ppm)	370	1.842	0.316	4.7	80
Rate of Concentration Change (ppm/yr)	1.5	0.007	0.0008	0.24	1.0

Source: US EPA: US Emissions Inventory 2005
<http://yosemite.epa.gov/oar/globalwarming.nsf/>

Why worry, doesn't the ocean absorb most of the CO₂?

Yes. But the ocean can only absorb so much depending on its temperature and current saturation. Warming oceans hold less.

Ouch - 2010 is the first year that the oceans did not absorb as much CO₂ as in other years.

The ocean is becoming more acidic. The pH of the ocean is changing. Scientists hypothesize that some creatures will be less likely to absorb Carbon compounds for their shells in an acidic environment.

Feedback Loops

- 1. Warming ..ice melting & more land or water surfaces exposed ..
More warming due to lower albedo of dark surfaces.**
- 2. Warming ... warmer ocean temps. ...less ability to absorb CO2
.... More CO2 left in the atmosphere ... more warming.**
- 3. Warming ... permafrost thawing ... releasing methane gas (22x's
more warming than CO2 Additional warming.**
- 4. Warming Drought ... death of plants... release of more CO2
and less CO2 absorption ... more warming.**
- 5. Warming ... increased bark beetle tree deaths ... release of CO2
due to dead tree material decomposition & less CO2 absorption
.... More warming.**
- 6. Warming Clathrates (frozen ice with methane inside) thawing
& releasing methane ... more warming.**
- 7. Warming ... increased use of air conditioning ... more CO2
released ... more warming.**

8. More warming More evaporation ... more clouds

A. Low cumulous clouds ... warming effect.

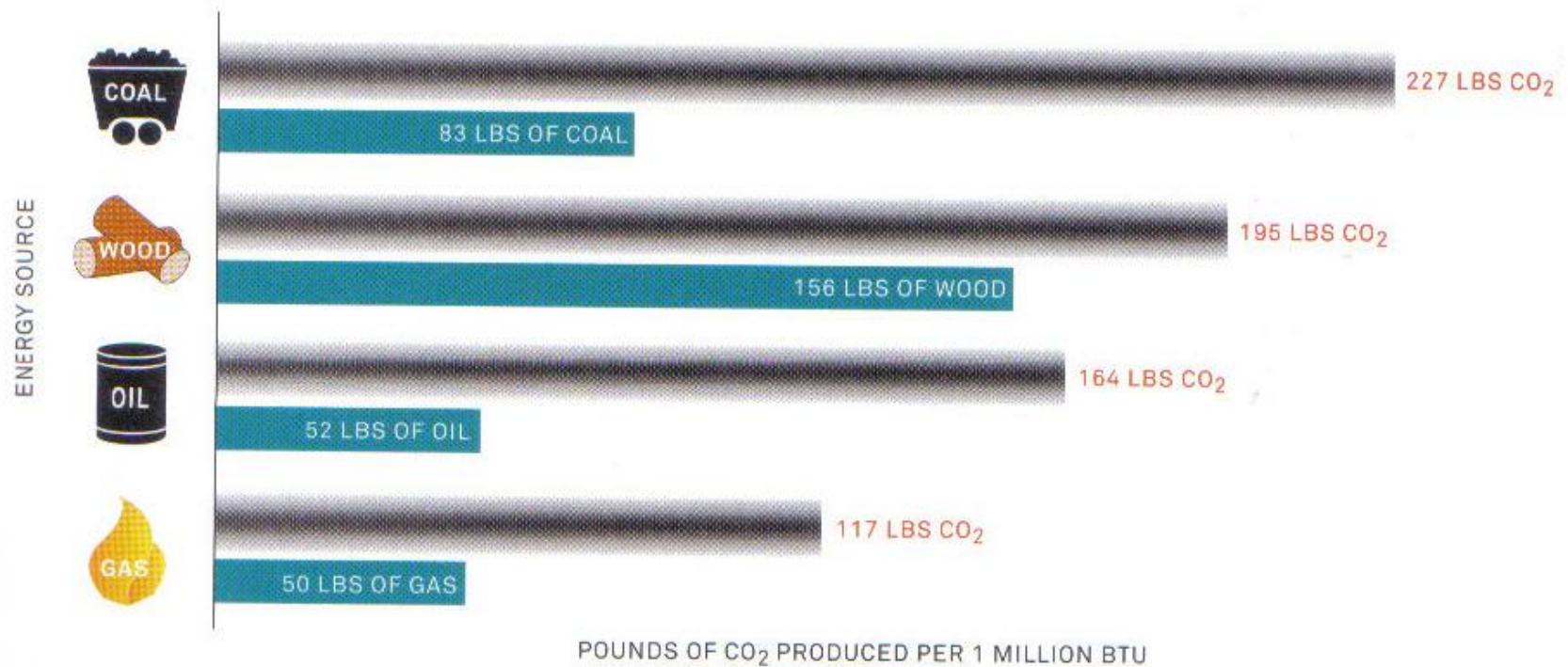
B. High Ice clouds ... cooling effect.

9. More warming ... DMS (dimethyl sulfide) released by ocean creatures Cooling effect.

10. More warming ... people become aware and use less energy, insulate, purchase cars with better mileage ... cooling effect VERY COOL!

CARBON DIOXIDE FROM CARBON-BASED FUELS

Our carbon-based fuels have very different characteristics. Oil and natural gas have more energy, pound for pound, than coal. But oil produces 40 percent more CO₂ than gas, and coal creates 40 percent more than oil. Wood, the only renewable carbon-based fuel, contains the least energy by weight.



SOURCE: University of California, Irvine; Oak Ridge National Laboratory; gas conversion: Tulsa Gas Technologies

Evidence:

<http://climate.nasa.gov/ClimateTimeMachine/ClimateTimeMachine.cfm>

Temperature changes.

- 1. Numerous long-term changes in the climate have been observed, including extreme weather such as droughts, heavy precipitation, heat waves and the intensity of tropical cyclones.**
- 2. Trends towards more powerful storms .**
- 3. Hotter, longer dry periods have been observed.**

Warmer temperatures mean greater evaporation, and a warmer atmosphere is able to hold more moisture -- hence there is more water aloft that can fall as precipitation. Similarly, dry regions are apt to lose still more moisture if the weather is hotter; this exacerbates droughts and desertification.

The decline of winter.

- 1. Average Arctic temperatures increased at almost twice the global rate in the past 100 years. Temperatures at the top of the permafrost layer have generally increased since the 1980s by up to 3°C. In the Russian Arctic, buildings are collapsing because permafrost under their foundations has melted.**

Snow cover has declined by some 10 per cent in the mid- and high latitudes of the Northern Hemisphere since the late 1960s. Mountain glaciers and snow cover have declined in both hemispheres and widespread decreases in glaciers and ice caps have contributed to sea level rise. New data evaluated by the IPCC shows that losses from the ice sheets of Greenland and Antarctica have very likely contributed to sea level rise from 1993 to 2003. The average global sea level rose at an average rate of 1.8 mm per year between 1961 and 2003, but between 1993 and 2003 it rose by 3.1 mm per year.

*** Almost all mountain glaciers in non-polar regions retreated during the 20th century. The overall volume of glaciers in Switzerland decreased by two-thirds.**

Shifts in the natural world *

Scientists have observed climate-induced changes in at least 420 physical processes and biological species or communities. * In the Alps, some plant species have been migrating upward by one to four meters per decade, and some plants previously found only on mountaintops have disappeared. *

In Europe, mating and egg-laying of some bird species has occurred earlier in the season -- in the United Kingdom, for example, egg-laying by 20 of 65 species, including long-distance migrants, advanced by an average of eight days between 1971 and 1995.

Across Europe, the growing season in controlled, mixed-species gardens lengthened by 10.8 days from 1959 to 1993. Butterflies, dragonflies, moths, beetles, and other insects are now living at higher latitudes and altitudes, where previously it was too cold to survive.

Core Evidence That Humans Affect Climate Change

Ice drilled in Antarctica offers the fullest record of glacial cycles and greenhouse gas levels.

An ice core about two miles long — the oldest frozen sample ever drilled from the underbelly of Antarctica — shows that at no time in the last 650,000 years have levels of the greenhouse gases carbon dioxide and methane been as high as they are today.

The research, published in today's issue of the journal *Science*, describes the content of the greenhouse gases within the core and shows that carbon dioxide levels today are 27% higher than they have been in the last 650,000 years and levels of methane, an even more powerful greenhouse gas, are 130% higher, said Thomas Stocker, a climate researcher at the University of Bern and senior member of the European team that wrote two papers based on the core.

Warming has increased most over the higher latitudes.

Spring occurs earlier & the frost free season is longer.

Night temperatures have increased more .

Extreme weather events have increased:

Heat waves & drought, flooding, hurricanes & tornadoes.

Sea-level rise is due to: A. Thermal expansion B. Fresh water additions. C. Coastal land subsidence.

Disappearance of sea ice & its blocking effect of land-based ice.

Coral reef bleaching & death.

Plant and animal ranges changing.

Permafrost thawing.

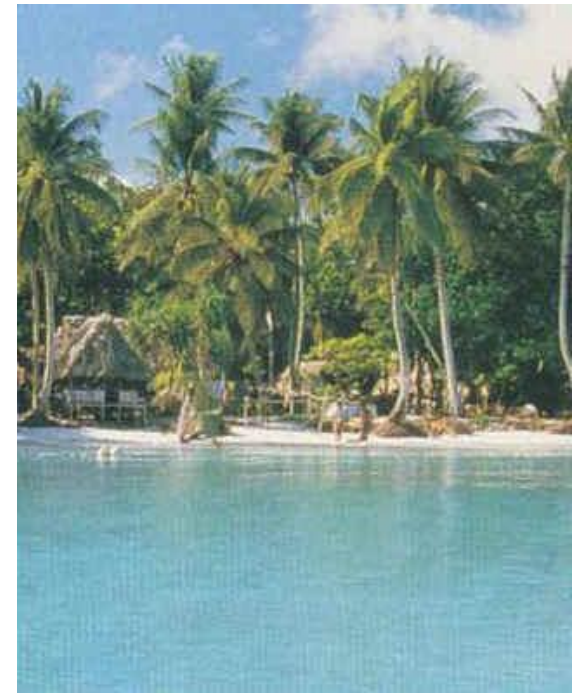
Disease vectors & disease spreading.

Effects of global climate change

Watery and grave

Low-lying atolls in the Pacific and Indian Oceans are already threatened. The first environmental refugees of the greenhouse century could come from a place like the Carteret (or Tulun) islands of Papua New Guinea.

The island's 1,400 residents say the rising sea has polluted their gardens with salt water, and they may starve even before the sea inundates their homes. The residents have applied for relocation money, but the government says it lacks the cash.



Rising seas also endanger the Pacific nation of Tuvalu, which may sue the developed world that creates most greenhouse gas pollution. The David-and-Goliath lawsuit would be hard to win, but it could raise the profile of island flooding.

The 9,300 residents are slowly re-locating to New Zealand & Australia.

