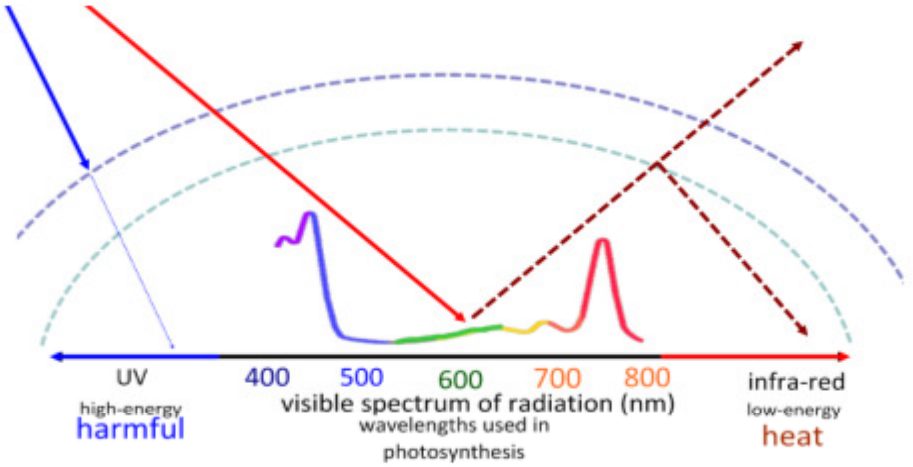
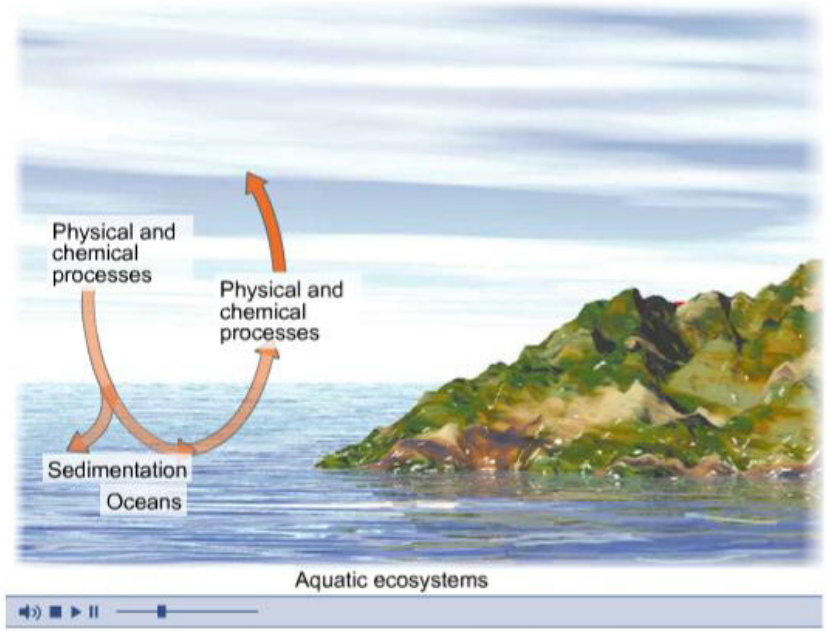


The Greenhouse Effect

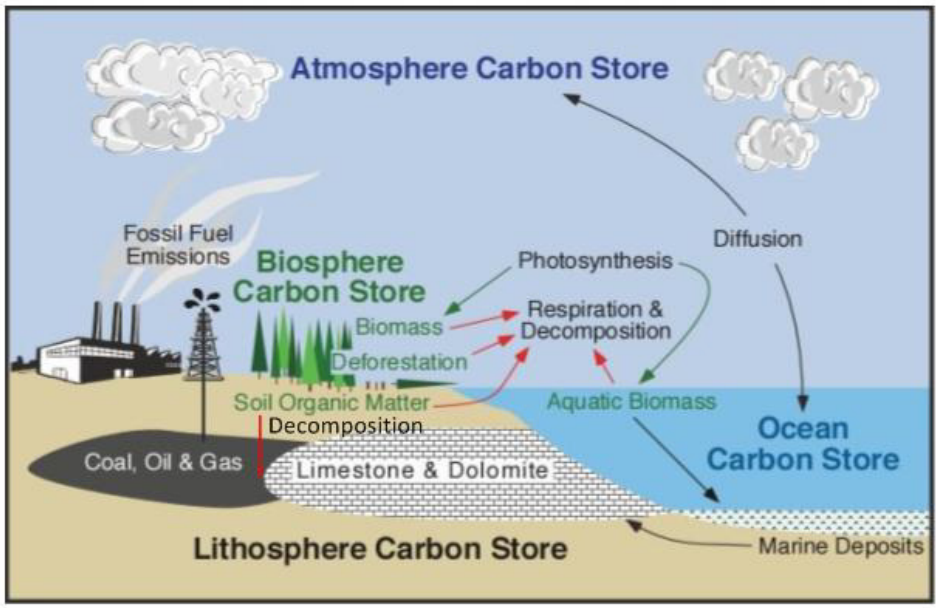
The Carbon Cycle

Carbon exists in many forms:
- atmospheric gases (CO_2 and methane)
- dissolved CO_2 in aquatic systems
- organic carbon in living organisms
- carbons deposits in the lithosphere, as minerals (carbonates) or fossil fuels.

Carbon cycle animation:



http://www.nodvin.net/snhu/SCI219/demos/Chapter_3/Chapter_03/Present/animations/51_1_2_1.html



http://www.physicalgeography.net/fundamentals/9r.html

What are the *sources* of atmospheric CO_2?

What is the *sink* of atmospheric CO_2?

Which *processes* return C to the lithosphere?

The Carbon Cycle

Carbon exists in many forms:
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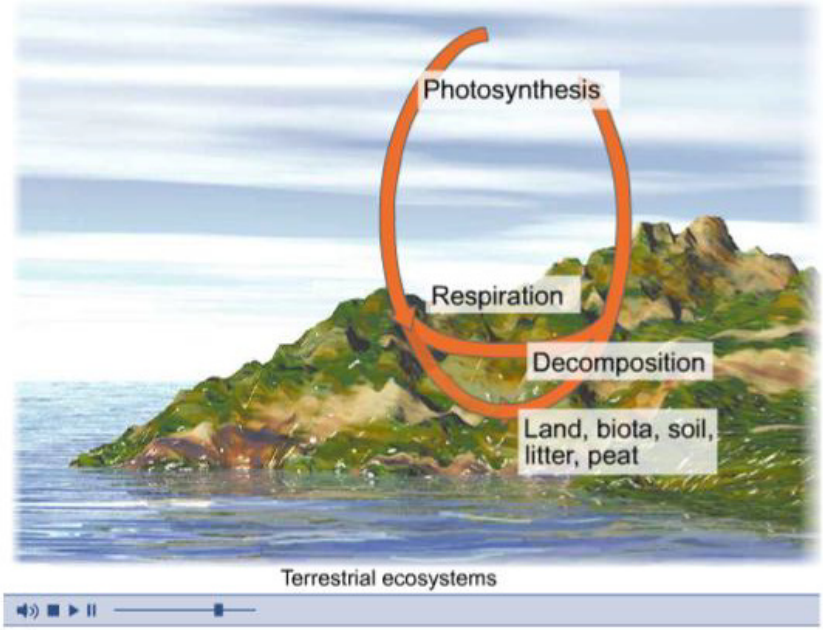
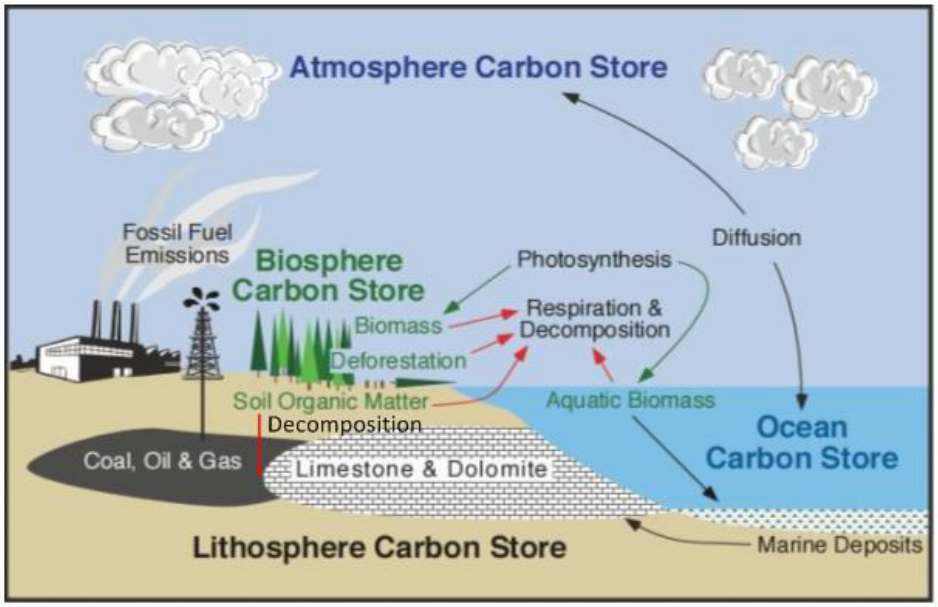
Carbon cycle animation:



http://www.nodvin.net/snhu/SCI219/demos/Chapter_3/Chapter_03/Present/animations/51_1_2_1.html



http://www.physicalgeography.net/fundamentals/9r.html

What are the *sources* of atmospheric CO_2?

respiration, decomposition, diffusion, burning of fossil fuels (combustion)

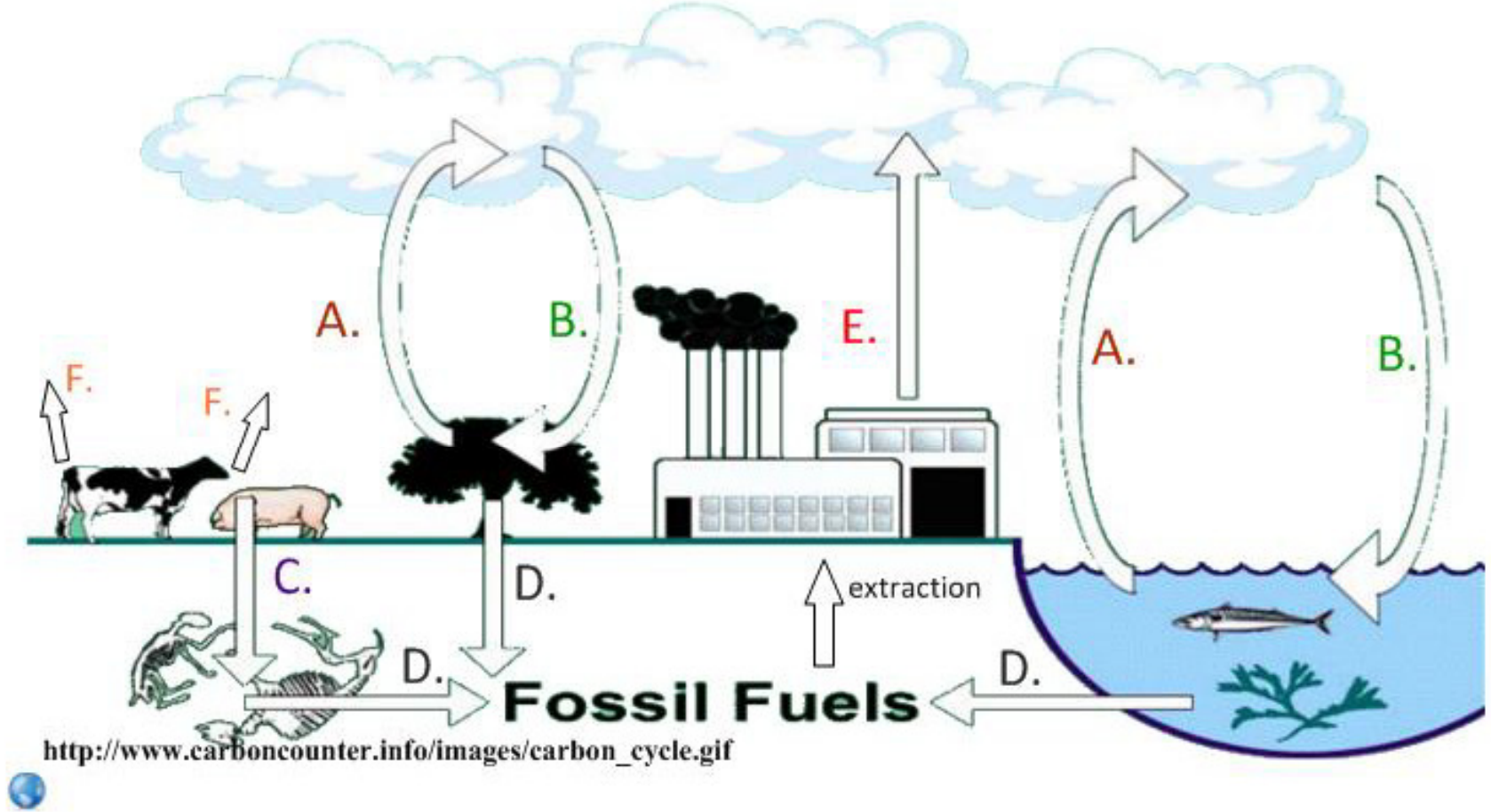
What is the *sink* of atmospheric CO_2?

photosynthesis,
some diffusion into aquatic systems

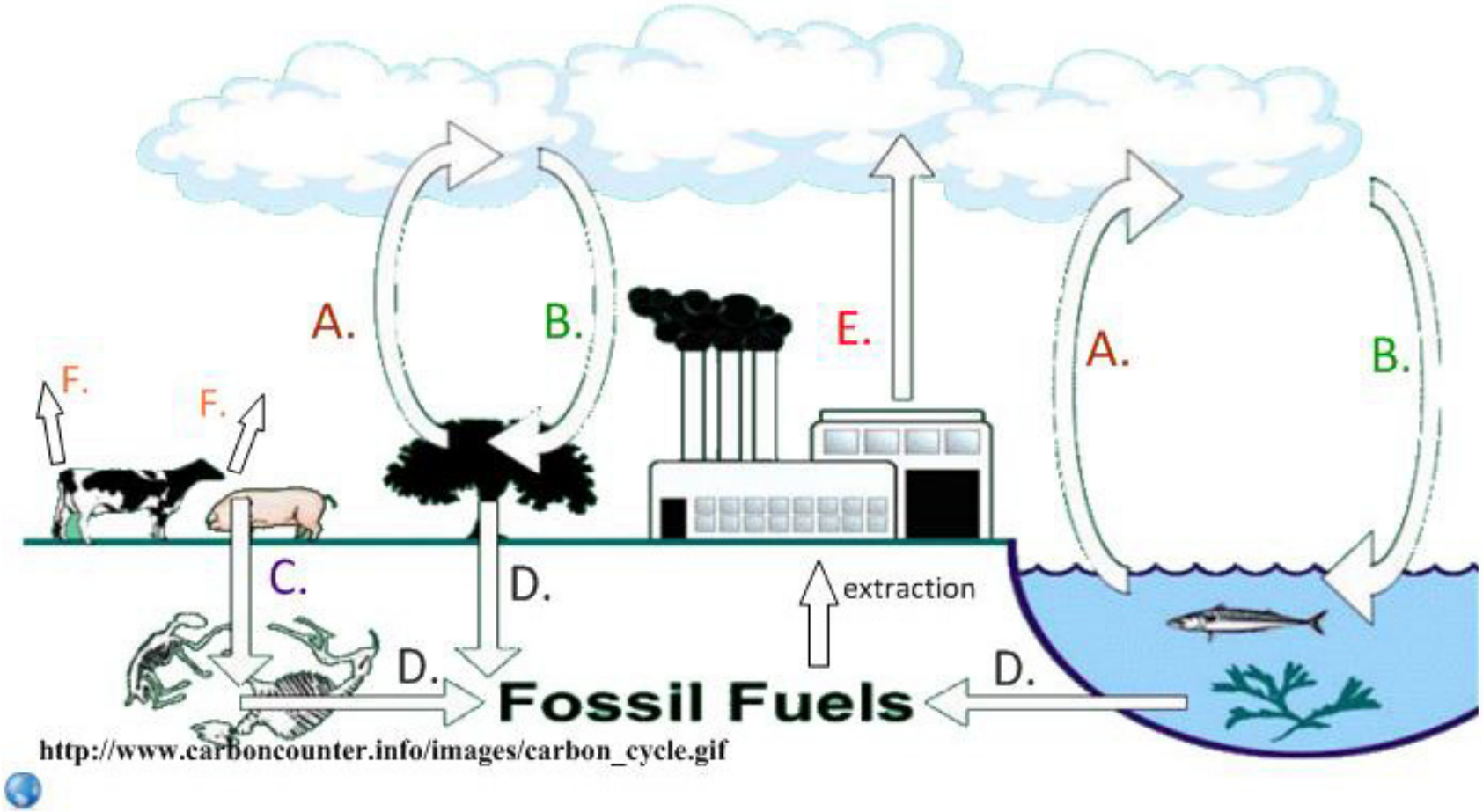
Which *processes* return C to the lithosphere?

decomposition of organic matter,
marine deposits of carbonates

A simplified carbon cycle

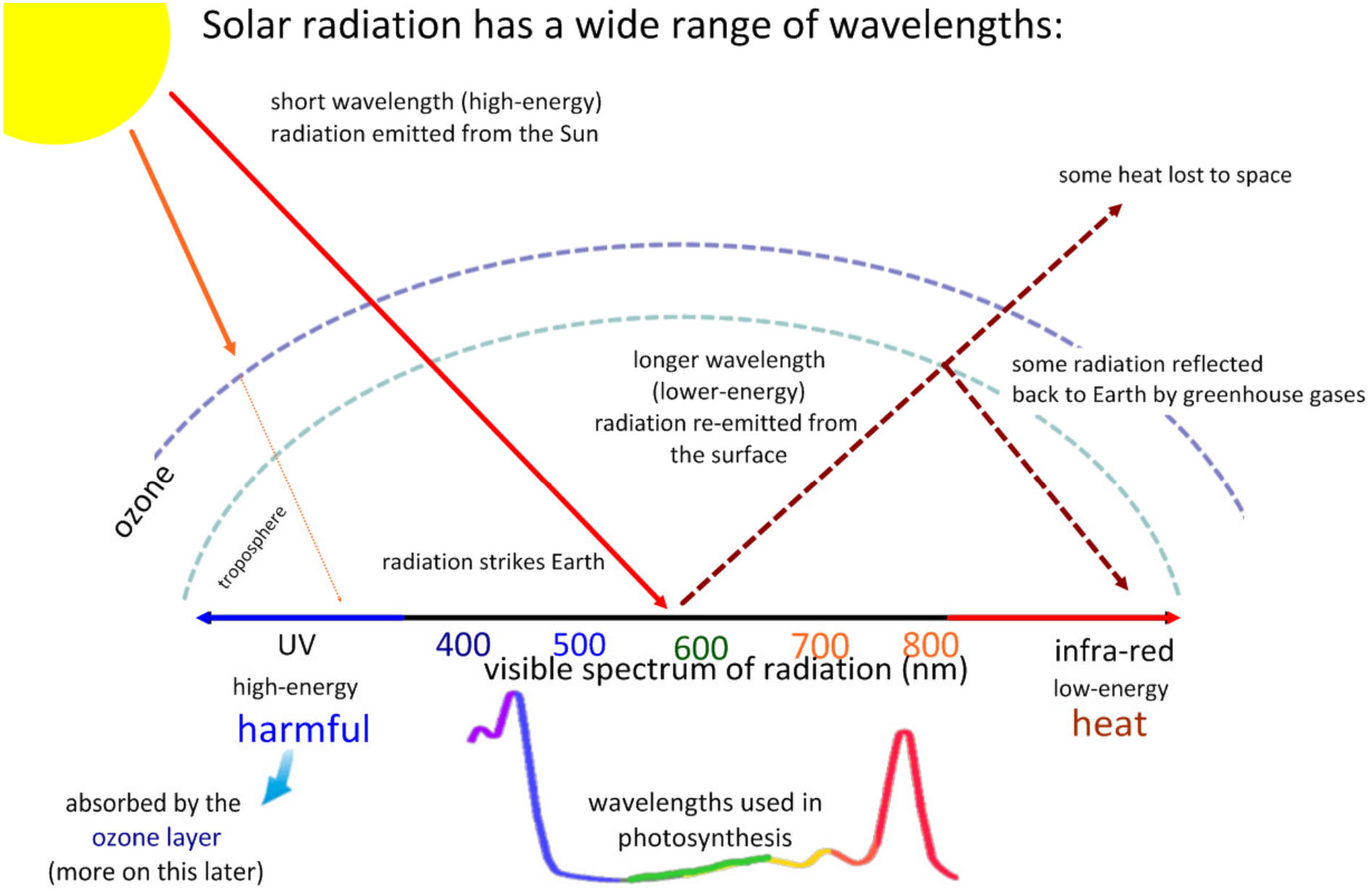


A simplified carbon cycle



A. Respiration
B. Photosynthesis (carbon fixation)
C. Decomposition
D. Fossilisation
E. Combustion
F. Methane emissions

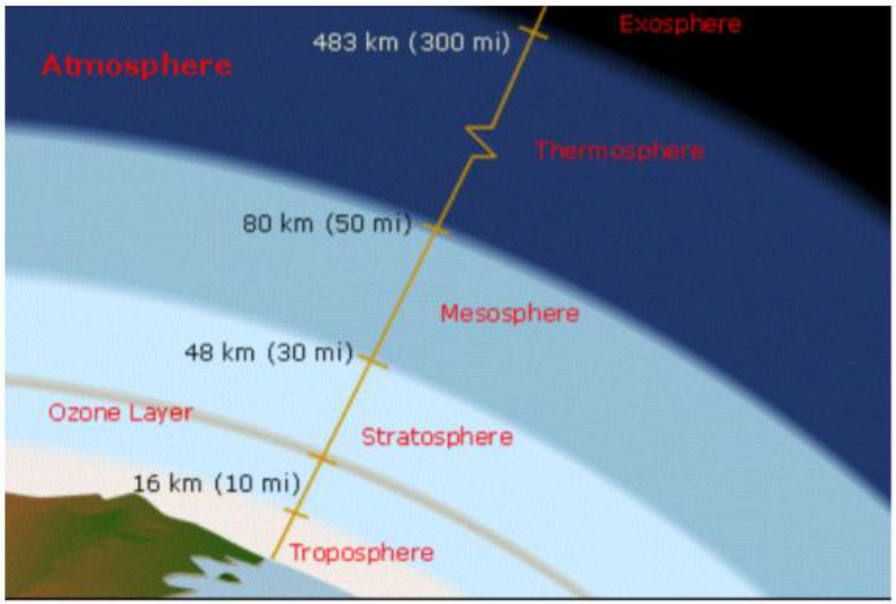
Solar radiation has a wide range of wavelengths:



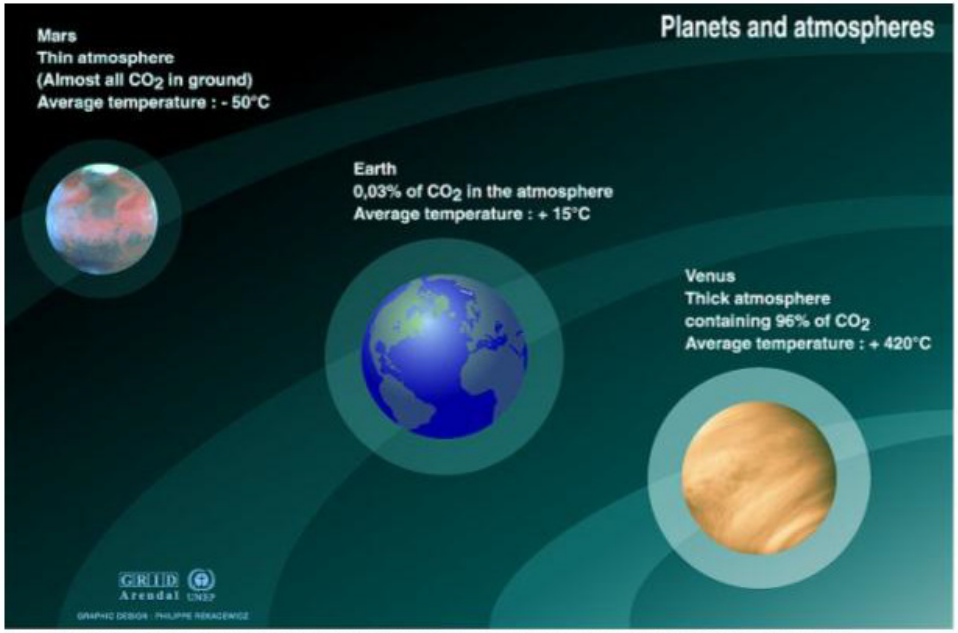
Greenhouse gases are trapped in the troposphere layer, up to 16km above the Earth's surface.

Greenhouse gases include:

- water vapour
- carbon dioxide (CO_2)
- methane (CH_4)
- nitrous oxide (NO_2)



http://www.pacificislandtravel.com/nature_gallery/atmosphere.html



http://www.grida.no/climate/vital/01.htm

The presence of greenhouse gases is vital to the evolution and survival of life on Earth.

Greenhouse gases trap radiation within the troposphere, raising temperatures.

Without the natural greenhouse effect, the temperature of the Earth would not be warm enough to sustain life.

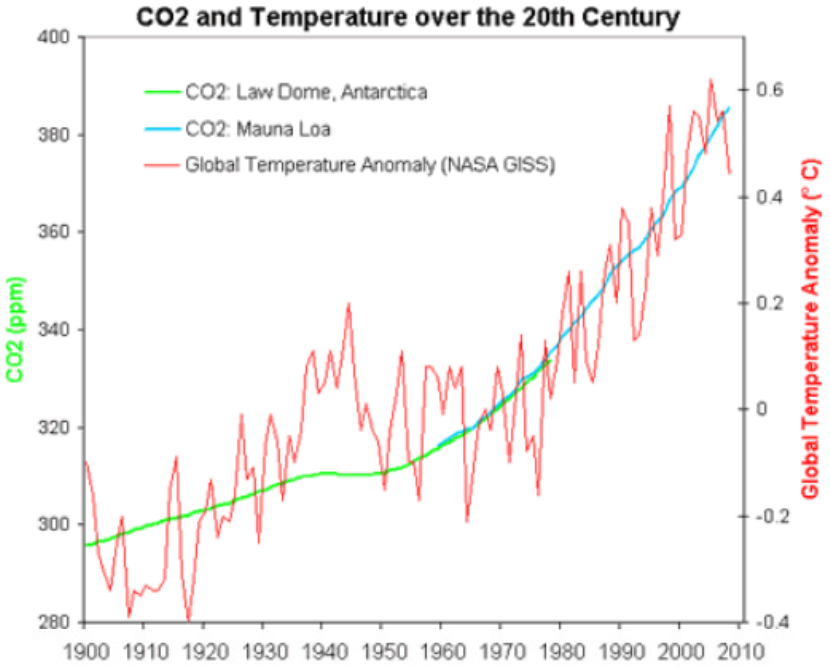
Elevated levels of greenhouse gases are strongly correlated with an enhanced greenhouse effect:

As levels of CO_2, methane, water vapour and oxides of nitrogen increase, more radiation is reflected back to Earth instead of being lost to space.

Anthropogenic = *human-caused*

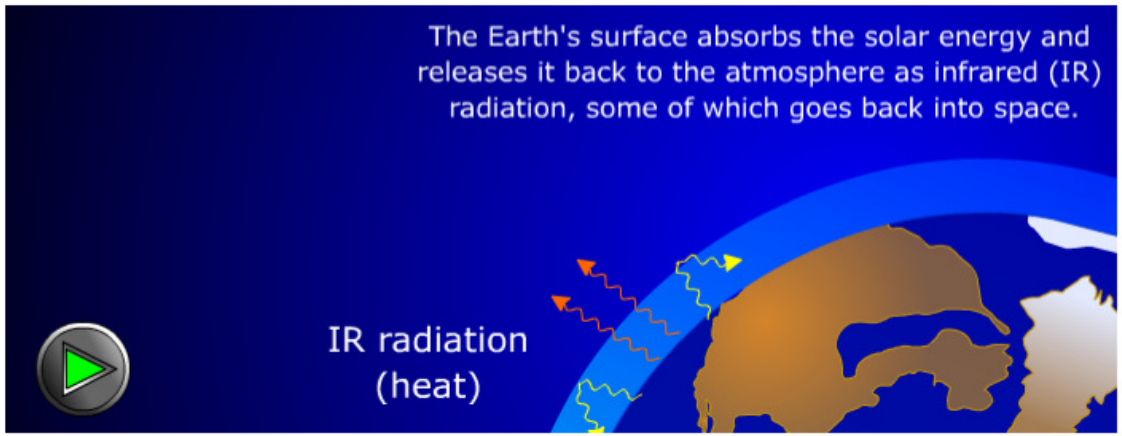
Which gases in the table have the potential to cause the most damage?

Although we see correlation, where do scientists find the evidence for a causal relationship?

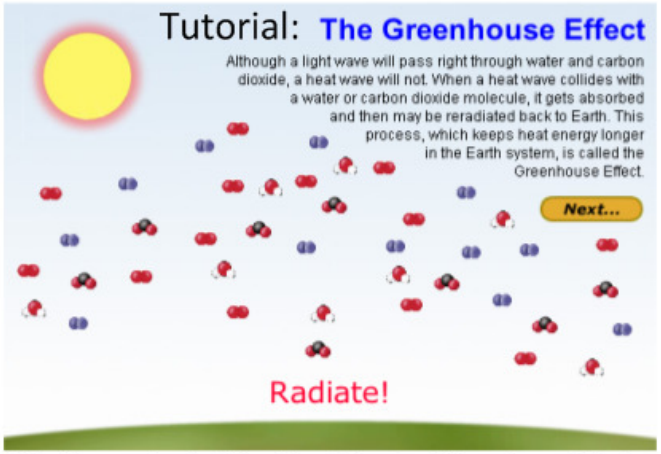


http://www.skepticalscience.com/The-CO2-Temperature-correlation-over-the-20th-Century.html

More greenhouse effect tutorials:

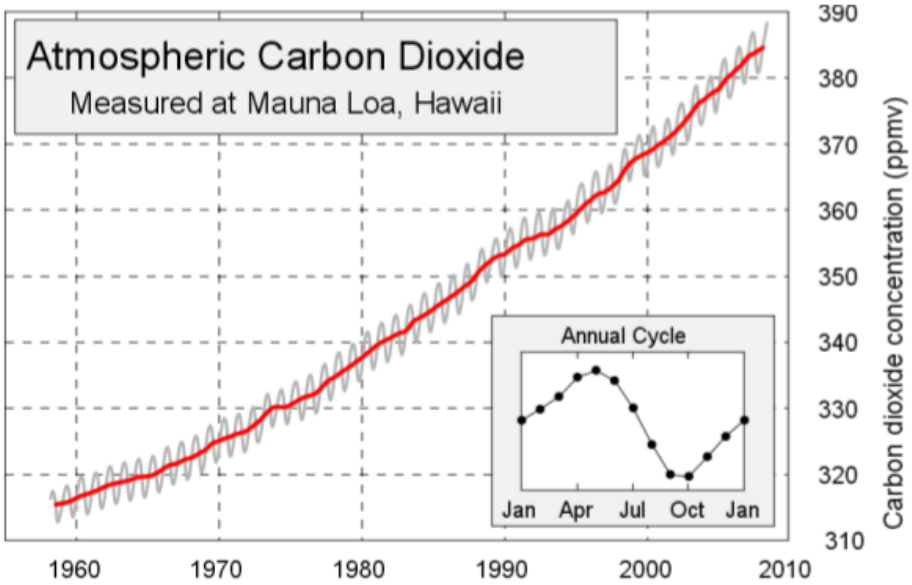


http://earthguide.ucsd.edu/earthguide/diagrams/greenhouse/



http://www.planetguide.net/book/chapter_3/greenhouse1.html

What is the evidence for increasing levels of CO_2 in the atmosphere?



http://icestories.exploratorium.edu/dispatches/ipy-the-next-generation/

Recent data has been easy to collect experimentally.

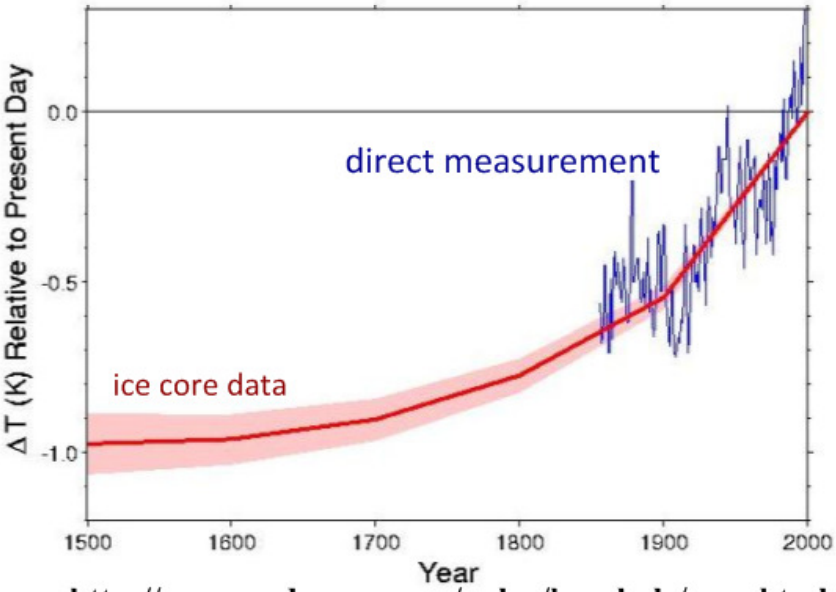
Over 40 years, Charles Keeling measured atmospheric CO_2 from his observatory in Mauna Loa, Hawaii, and the 'Keeling Curve' has become an icon of climate science.

It shows a clear trend and annual cycles and may field stations use a standardised method.

http://www.aslo.org/photopost/showphoto.php/photo/620

Historical data takes more effort to collect and is more variable in the reliability of the results produced.

Ice cores are a good source of CO_2 data, where researchers can analyse the CO_2 concentration of air bubbles trapped in the ice and estimate year based on the depth of the core.



http://www.ncdc.noaa.gov/paleo/borehole/core.html

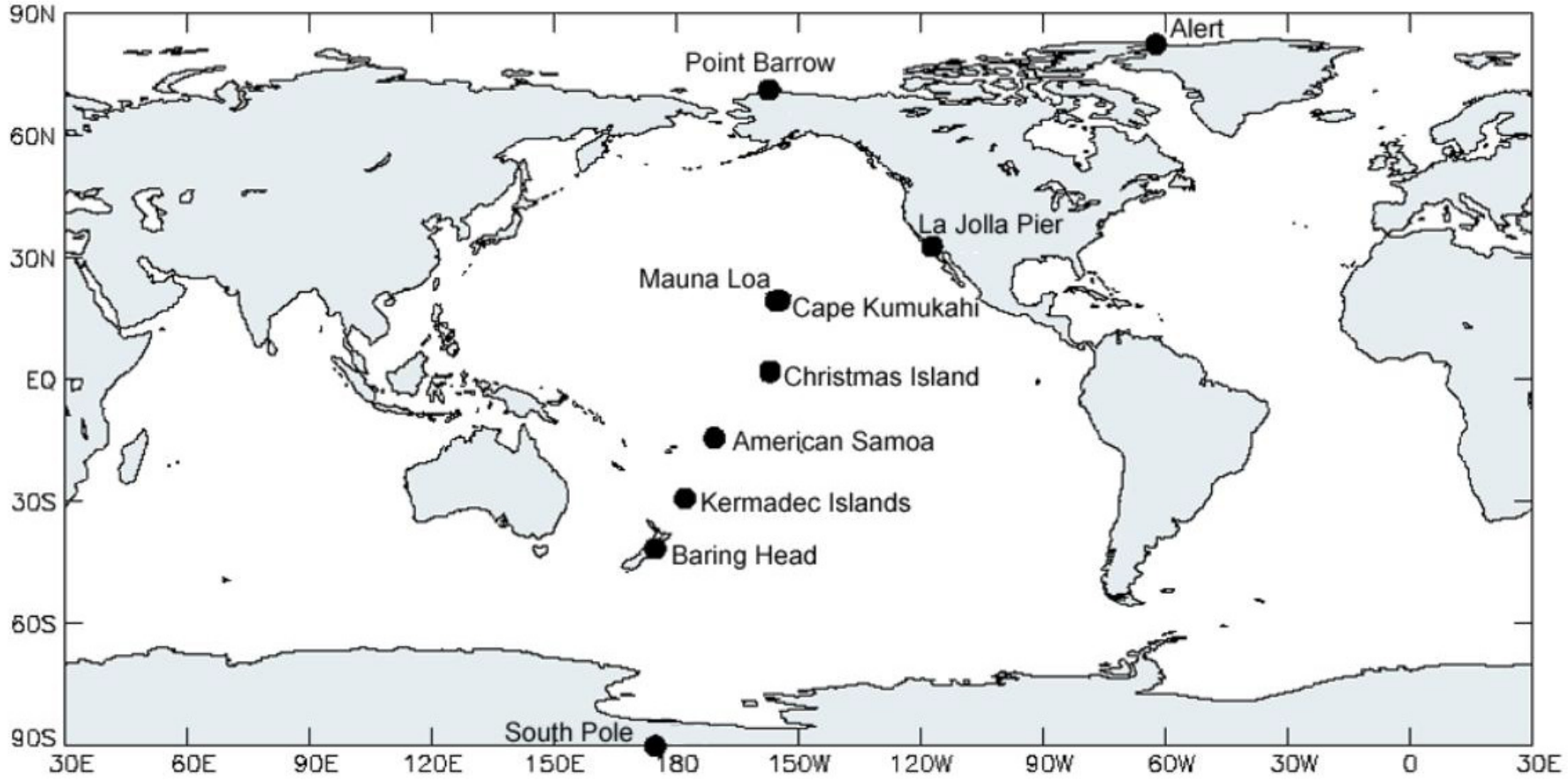
Plot annual fluctuations and long-term trends for one of these sites:

32°9' N, 117°3' W

19°32' N, 155°35' W

89°59' S, 178E

Scripps Institution of Oceanography monitoring sites

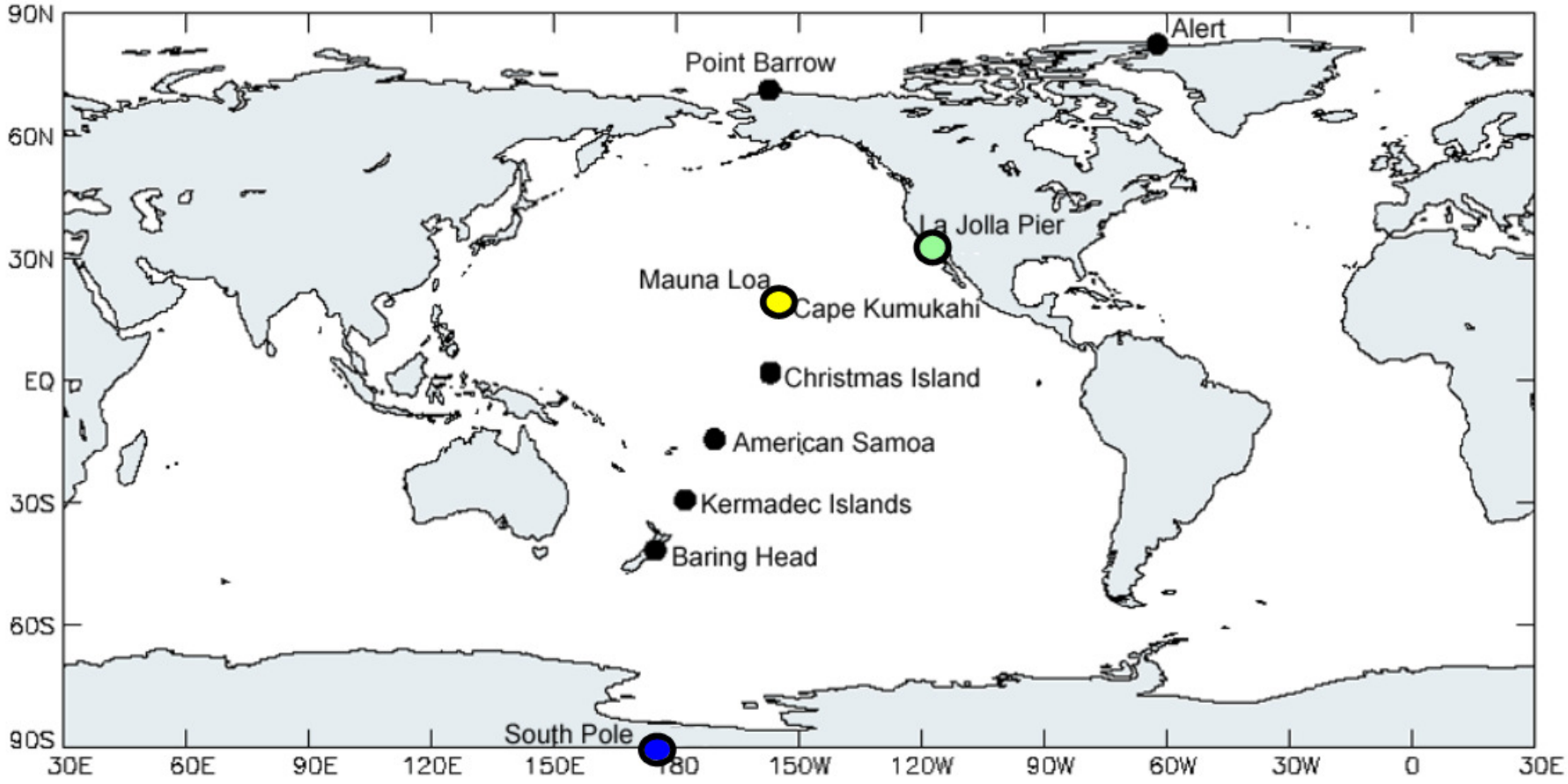


http://cdiac.ornl.gov/trends/co2/sio-keel.html

Plot annual fluctuations and long-term trends for one of these sites:

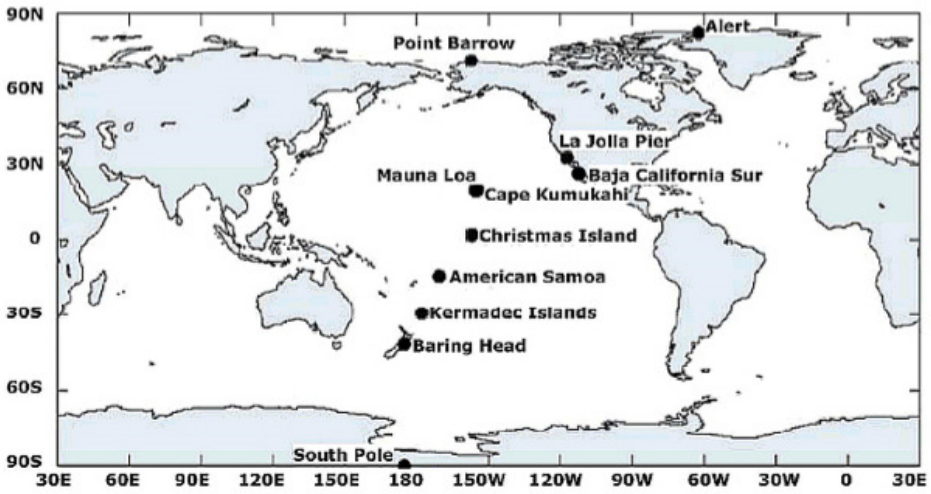
- La Jolla Pier
  32°9' N, 117°3' W
- Mauna Loa, Hawaii
  19°32' N, 155°35' W
- The South Pole
  89°59' S, 178E

Scripps Institution of Oceanography monitoring sites



http://cdiac.ornl.gov/trends/co2/sio-keel.html

Data analysis task: Atmospheric CO_2 measurements



http://cdiac.ornl.gov/trends/co2/sio-keel.html

The Carbon Dioxide Information Analysis Centre (CDIAC) has a huge database of information regarding carbon dioxide measurements.

In this task, use one set of data from their field observatories in this list:

http://cdiac.ornl.gov/trends/co2/sio-keel.html

Visit the webpage and make notes on:

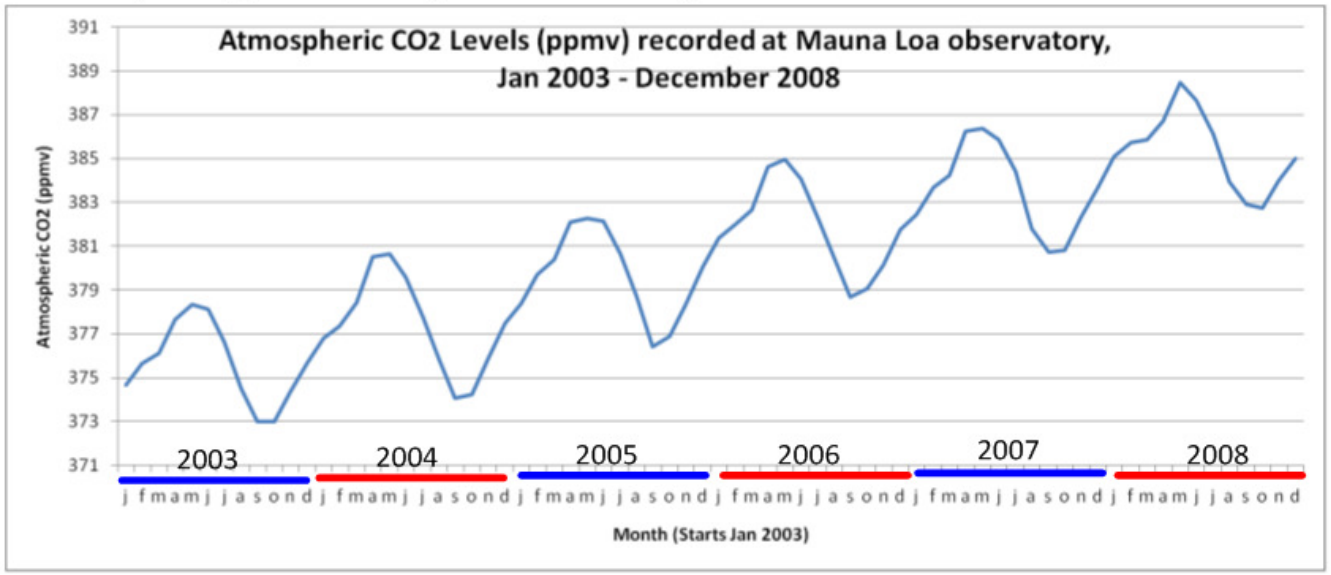
- Station name
- Coordinates
- Period of record
- Situation (type of environment)

Using the spreadsheet:

- Open the digital data page
- Select all data for the past 5 years
- Paste into Excel (one giant row)
- Adjust the spreadsheet to make sure that all columns and rows are correct
- Produce a line graph, presented to meet requirements for Presenting Processed Data

Look at the graphics for the overall trends. What trends can you see?
Using your own graph, explain the annual cycles in the data.

Analysing atmospheric CO_2 data:



Mauna Loa, Hawaii

Period of record: 1958-2008

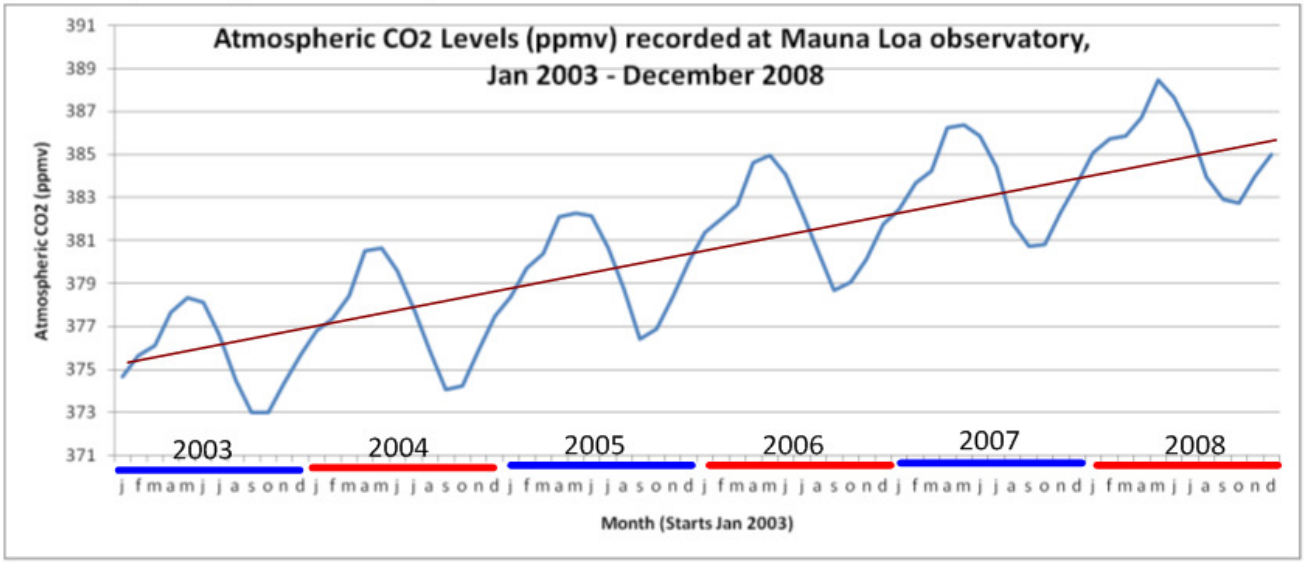
Barren lava field of an active volcano

http://cdiac.ornl.gov/trends/co2/sio-keel.html

Trend:

Annual fluctuations:

Analysing atmospheric CO_2 data:



Mauna Loa, Hawaii

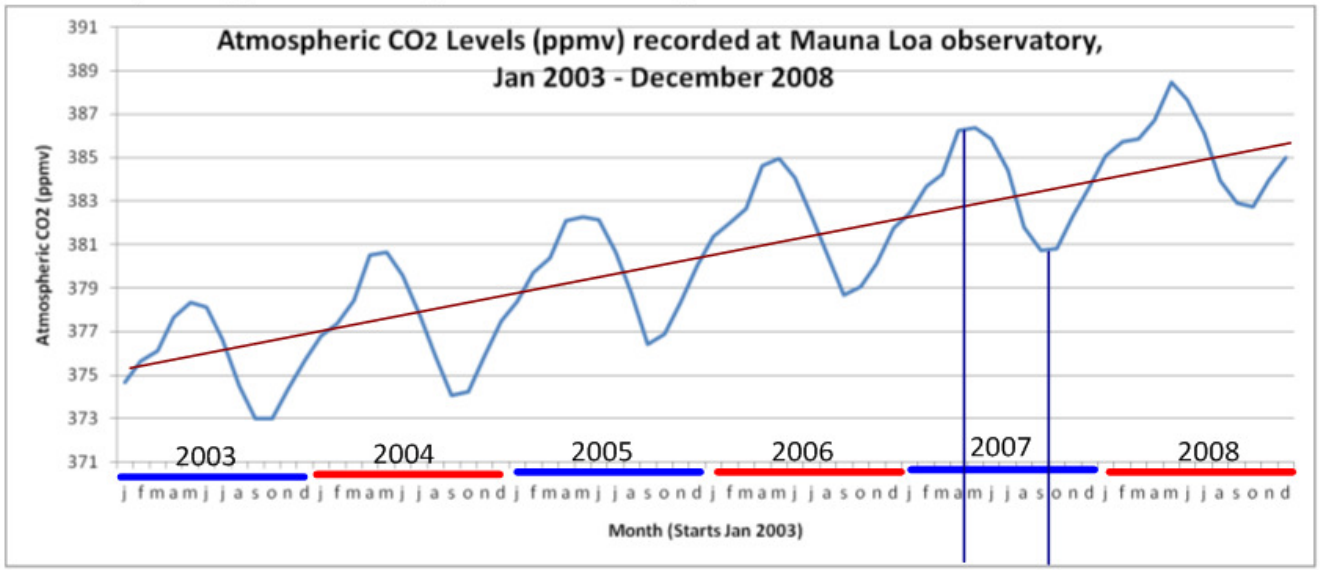
Period of record: 1958-2008

Barren lava field of an active volcano

Trend: There is an increase in atmospheric CO_2 at Mauna Loa, year-on-year

Annual fluctuations:

Analysing atmospheric CO_2 data:



Mauna Loa, Hawaii

Period of record: 1958-2008

Barren lava field of an active volcano

Trend: There is an increase in atmospheric CO_2 at Mauna Loa, year-on-year

Annual fluctuations: Annual troughs in CO_2 correspond with northern-hemisphere summers. The northern hemisphere has the greatest land mass and at this time of the year, more trees and others plants in leaf. This increased amount of foliage leads to increased photosynthesis, and therefore a greater sink of CO_2 from the atmosphere. Annual peaks correspond with winters.

Use this database to seach for ice-core data:

NOAA Satellite and Information Service
National Environmental Satellite, Data, and Information Service (NESDIS)
National Climatic Data Center
U.S. Department of Commerce

WDC for Paleoclimatology

Search NCDC

Home • Research • Data • Education • What's New • Features • Perspectives • Site Map

Ice Core Data Search

Use this form to search our online Ice Core data collection. The search results will be presented as a list of matched files, which can then be clicked for transfer to your computer. For more information visit our Ice Core pages.

Start Search | Reset Form | Help | Match Limit: 50 100 250 500

Site Name

Sites with Data for Calendar Years ≤ ≥

Latitude/Longitude

90N

180W 180E

90S

Variable: (All), 3H, 10-Be, 14-C, 15-N, Accumulation Rate

Investigator: (All), Alley, R.B., Anklin, M., Arkhipov, S.M., Banta, J.R., Barlow, L.K.

Altitude (m) ≥ ≤

Country: (All), Antarctica, Bolivia

Other Searches

Privacy Policy | How are we doing? A user survey | FIRSTGOV | Disclaimer

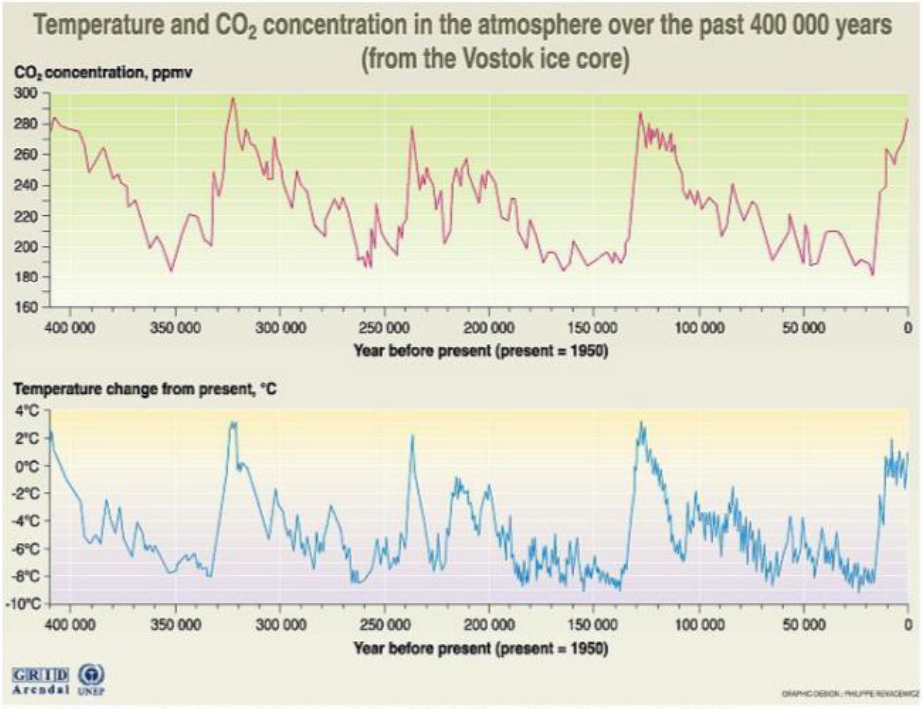
http://hurricane.ncdc.noaa.gov/pls/paleo_dev/fm_createpages.treering
Page Generated: Wednesday, 27-Aug-2008 08:38:05 pm EDT by paleo@noaa.gov
Please see the Paleoclimatology Contact Page or the NCDC Contact Page if you have questions or comments.

http://hurricane.ncdc.noaa.gov/pls/paleo/fm_createpages.icecore

Another chance to use databases in IB Biology

Scientists inspecting an ice core

http://www.treehugger.com/ice-core-inspection.jpg



Source: J.R. Petit, J. Jouzel, et al. Climate and atmospheric history of the past 420 000 years from the Vostok ice core in Antarctica, Nature 399 (3JUne), pp 429-436, 1999.

http://www.grida.no/climate/vital/index.htm

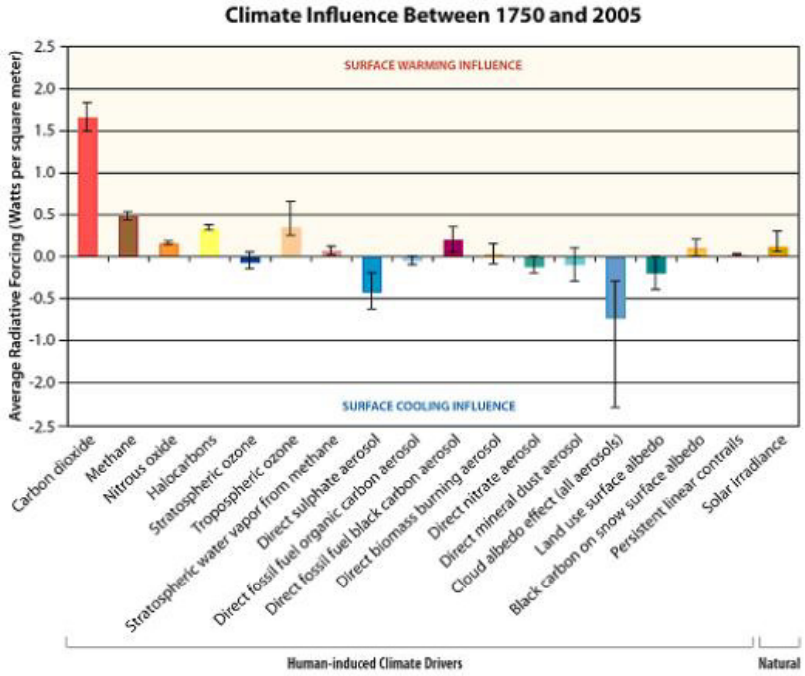
Drill deeper:

Find out how researchers genarate CO2 data from trapped gas bubbles in ice cores.

How do they estimate temperature?

- http://www.youtube.com/watch?v=VjTsj-fi-p0
- http://www.youtube.com/watch?v=oHzADl-XID8

What are the relative warming and cooling effects of various gases?



Source: IPCC 2007 WGI Table 2.12; Figure: Union of Concerned Scientists

http://www.ucsusa.org/global_warming/science_and_impacts/science/CO2-and-global-warming-faq.html

Although many gases, *natural* and *anthropogenic*, play a role in the enhanced greenhouse effect, scientists are most concerned about carbon dioxide, methane and nitrous oxides.

Where other gases, such as CFCs have more potential for damage, they are produced in smaller amounts.

The focus on CO2 is understandable:

- it remains in the atmosphere for extended lengths of time
- it is produced in huge quantities
- it is familiar and easy to communicate its importance to the public

The main greenhouse gases

Greenhouse gases	Chemical formula	Pre-industrial concentration	Concentration in 1994	Atmospheric lifetime (years)***	Anthropogenic sources	Global warming potential (GWP) *
Carbon-dioxide	CO_2	278 000 ppbv	358 000 ppbv	Variable	Fossil fuel combustion Land use conversion Cement production	1
Methane	CH_4	700 ppbv	1721 ppbv	12,2 +/- 3	Fossil fuels Rice paddies Waste dumps Livestock	21 **
Nitrous oxide	N_2O	275 ppbv	311 ppbv	120	Fertilizer industrial processes combustion	310
CFC-12	CCl_2F_2	0	0,503 ppbv	102	Liquid coolants Foams	6200-7100 ****
HCFC-22	$CHClF_2$	0	0,105 ppbv	12,1	Liquid coolants	1300-1400 ****
Perfluoromethane	CF_4	0	0,070 ppbv	50 000	Production of aluminium	6 500
Sulphur hexa-fluoride	SF_6	0	0,032 ppbv	3 200	Dielectric fluid	23 900

Note : pptv:: 1 part per trillion by volume; ppbv:: 1 part per billion by volume, ppmv:: 1 part per million by volume

* GWP for 100 year time horizon, ** Includes indirect effects of tropospheric ozone production and stratospheric water vapour production, *** On page 15 of the IPCC SAR. No single lifetime for CO_2 can be defined because of the different rates of uptake by different sink processes, **** Net global warming potential (i.e., including the indirect effect due to ozone depletion).

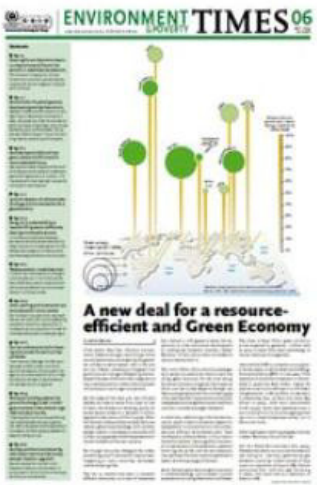
GRID Arendal UNEP

Source: IPCC radiative forcing report , Climate change 1995. The science of climate change, contribution of working groups 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge press university, 1996.

http://www.grida.no/climate/vital/05.htm

UN Environmental Programme: Useful Stats and Graphs

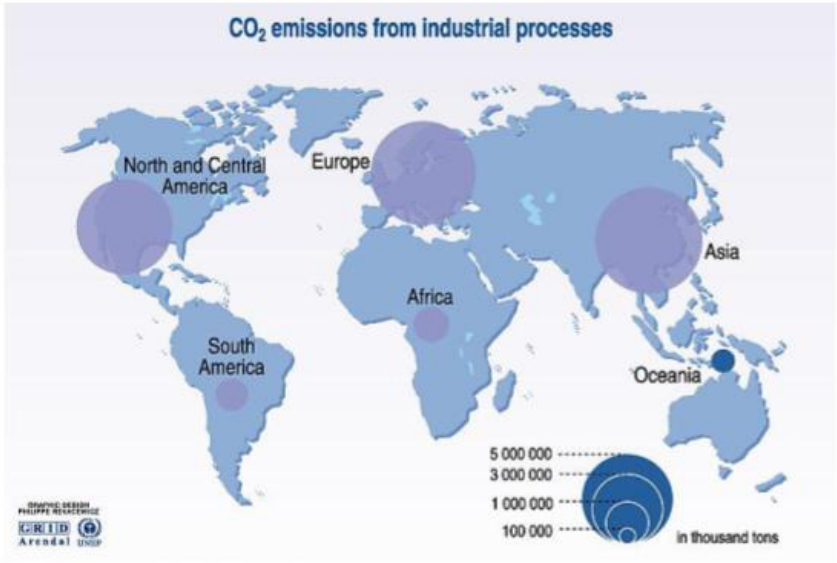
Some great resources here to relate environmental impacts to poverty and human issues.



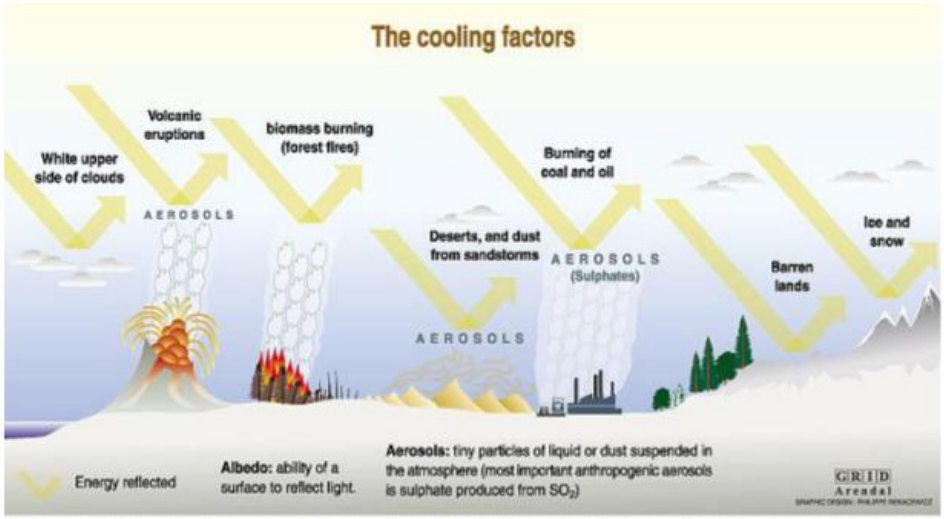
The Environment and Poverty times:

How are the effects of environmental change impacting the lives of those in developing nations and in poverty?

http://www.grida.no/publications/et/ep6/

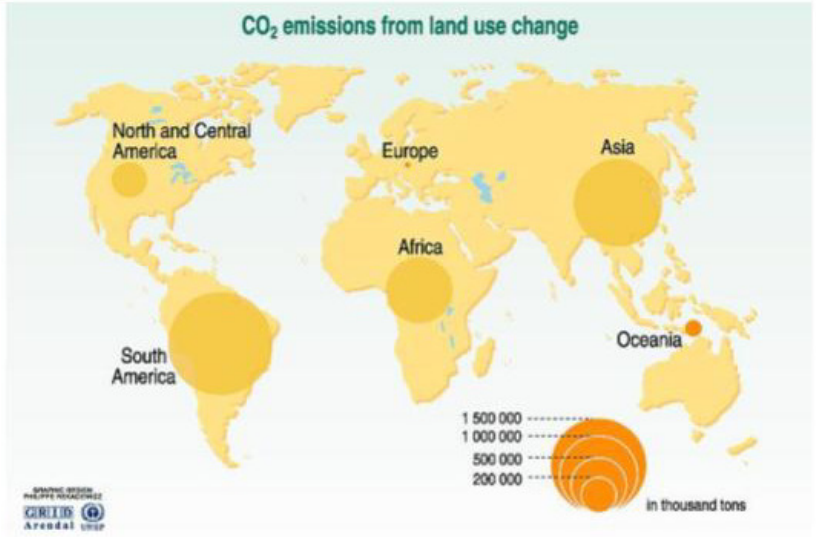


http://www.grida.no/climate/vital/09.htm



Sources: Radiative forcing of climate change, the 1994 report of the scientific assessment working group of IPCC, summary for policymakers, WMO, UNEP; L.D. Danny Harvey, Climate and global environmental change, Prentice Hall, pearson Education, Harlow, United Kingdom, 2000.

http://www.grida.no/climate/vital/14.htm



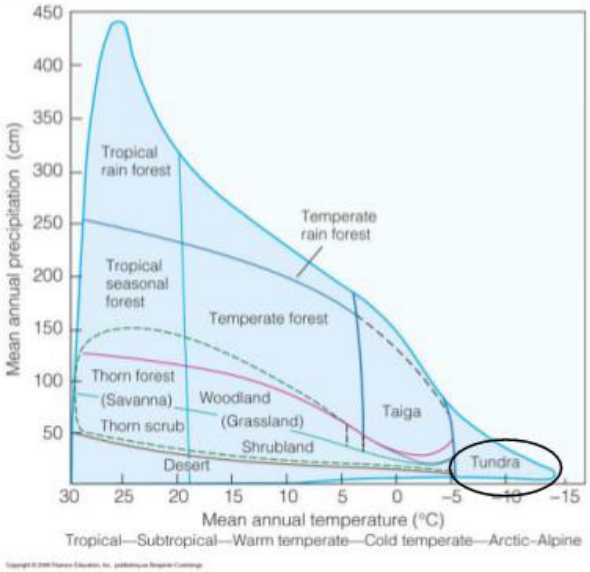
Source : Climate Change information kit, UNEP IUC, 1997.

http://www.grida.no/publications/vg/climate/page/3064.aspx

What are the consequences of global temperature increases on arctic ecosystems?

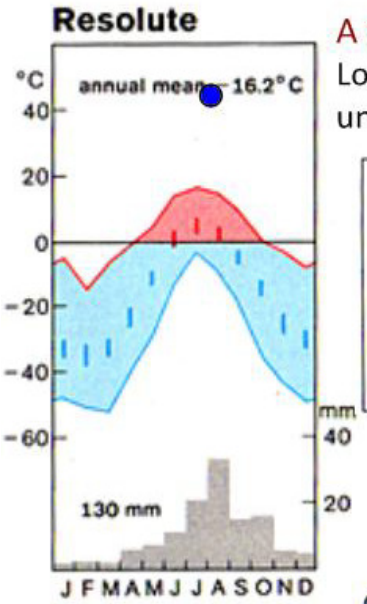
Increased global temperatures will result in a shift of characteristics of the world's biomes.

Critically, geographical regions will develop the characteristics of their warmer neighbouring biomes: the niches present in the area will no longer exist in the same form, resulting in a change in populations.

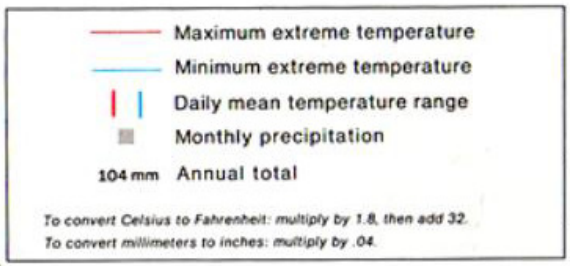


Let's look at the arctic ecosystems as an example of an environment under threat.

As temperatures and precipitation increase, there will be a shift in species present as new species migrate into the area to take advantage of new niche opportunities.

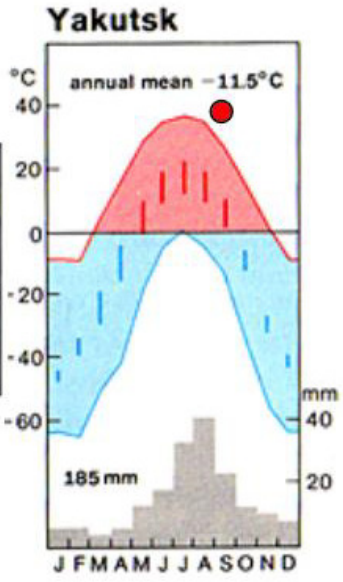


A regular polar ice-cap climograph:
Low precipitation and temperatures under 0°C all year.



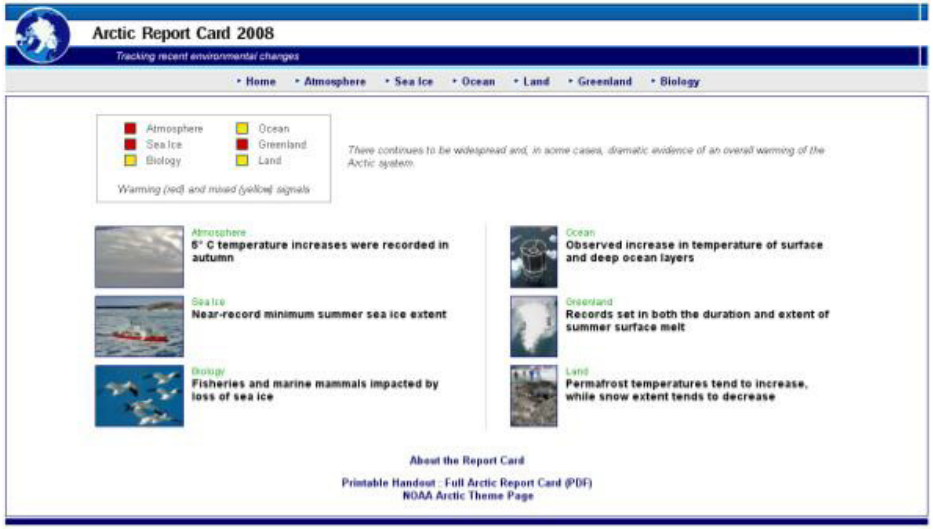
A sub-arctic climograph:
Higher annual precipitation and rainfall.
The future of the arctic ecosystems.

http://en.wikipedia.org/wiki/Climate_of_the_Arctic



The Arctic (including Arctic circle):

The Arctic Report Card



Produced annually by NOAA, the report card outlines climate data and changes in local physical and biological characteristics.

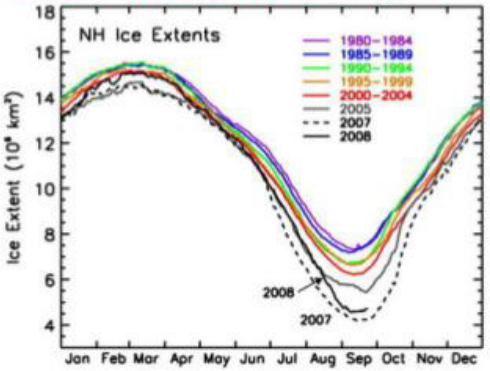
Key issues:

- Sea-ice and habitat loss
- Increased decomposition and release of organic matter from permafrost (further release of CO_2)

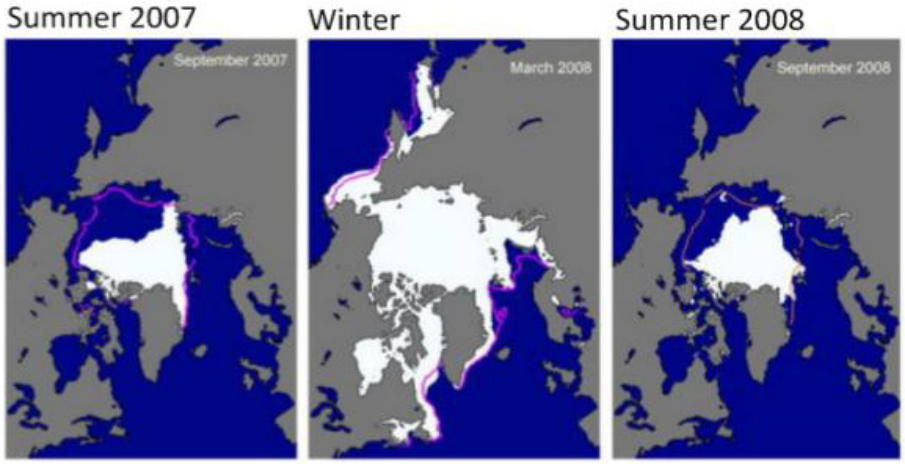
But:

- Redistribution of plant and animal species:
  - coniferous forests moving into arctic areas, more photosynthesis and sink of CO_2
  - migration of animal species, leading to food scarcity for arctic predators
  - fisheries changing structure from ice-requiring species to sub-arctic species (interspecific competition)
  - pest species are more successful, including bacteria and other pathogens

Seasonal sea-ice changes:



Year-on-year decrease of summer sea-ice coverage leads to habitat loss.



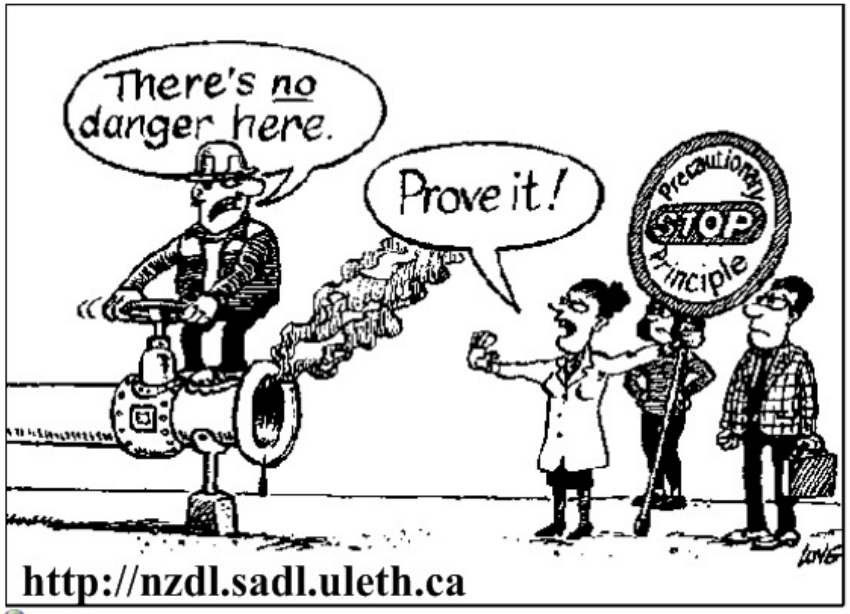
http://www.arctic.noaa.gov/reportcard/seaice.html

The Precautionary Principle:

If there is a chance that an action may do harm to people or the environment, it should be stopped until it is proven safe.

The burden of proof lies on those whose actions may possibly do harm.

It is their responsibility to provide evidence before they are allowed to carry on with their actions.



From the Wingspread statement:

"When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically. In this context the proponent of an activity, rather than the public, should bear the burden of proof."

"Not having the evidence is that something might be a problem is not a reason for not taking action."

Caroline Raffensperger at Bioneers discusses the Precautionary Principle:

http://www.youtube.com/watch?v=yAsH4Q7Njy8

In the case of global warming, we are collecting evidence daily that suggests that there is an anthropogenic component to the enhanced greenhouse effect.

The precautionary principle dictates that we should take action to reduce the human impacts on greenhouse gases as we gather more evidence for or against anthropogenic cause. This way, if (and it looks ever more likely) we prove a human impact, we have taken steps early to reduce harm.

If we do not take action and anthropogenic cause is proven, we have done more damage to the environment in the meantime.

The burden proof lies on all those individuals and organisations whose actions may be contributing to the problem.

Regardless of one's position on the climate change 'debate', it is the responsibility of all of us to be informed and to take steps towards a more sustainable, harm-reducing future.

"First, do no harm"

Primum non nocere

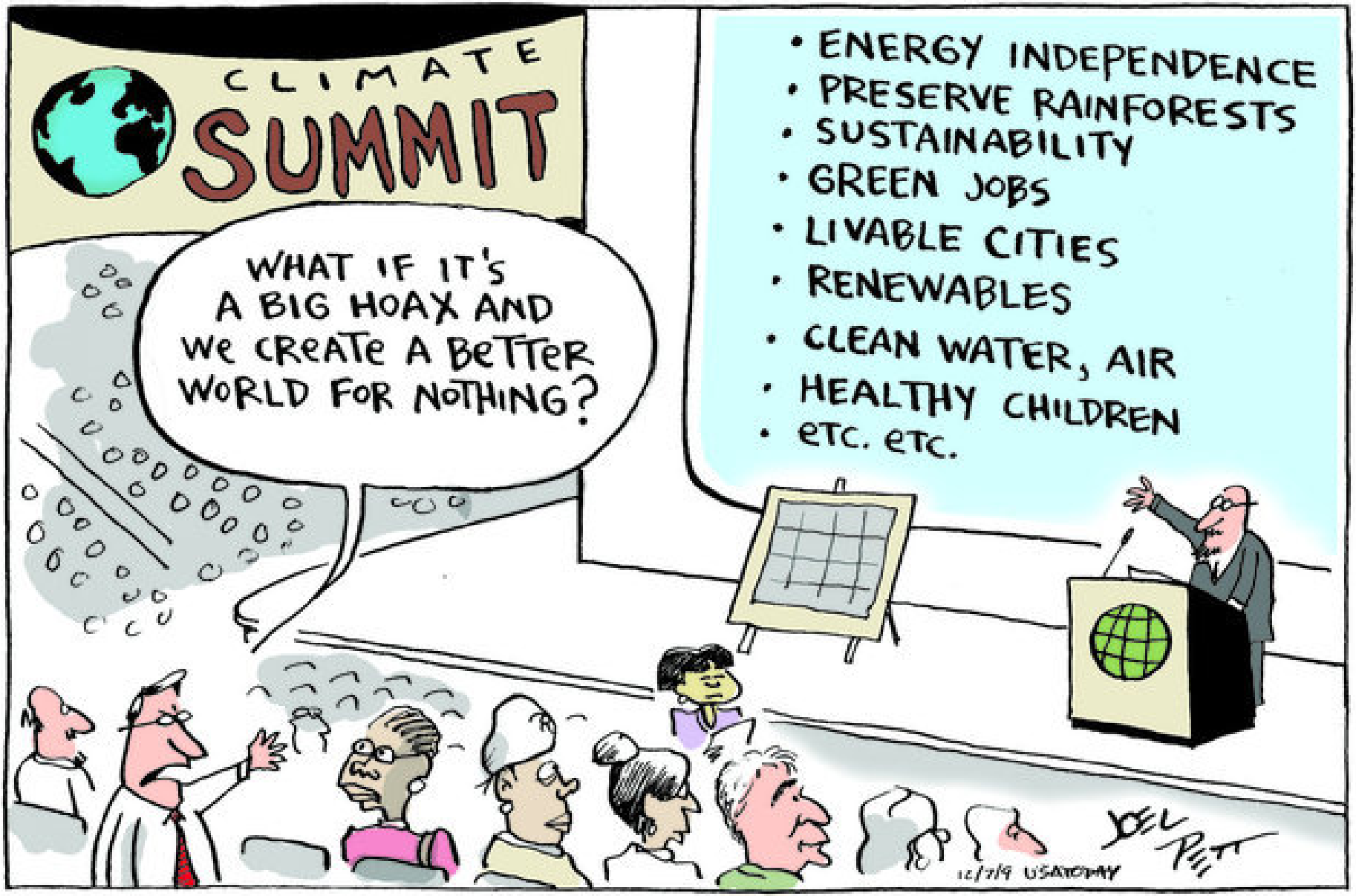
The hippocratic oath taken by doctors:
how does it relate to the precautionary principle?

image source unknown

Evaluating the Precautionary Principle:

How can we, as an international community, decide to do the right thing?

What are the pros and cons of taking action now, in line with the precautionary principle?


CLIMATE
SUMMIT
WHAT IF IT'S A BIG HOAX AND WE CREATE A BETTER WORLD FOR NOTHING?
• ENERGY INDEPENDENCE
• PRESERVE RAINFORESTS
• SUSTAINABILITY
• GREEN JOBS
• LIVABLE CITIES
• RENEWABLES
• CLEAN WATER, AIR
• HEALTHY CHILDREN
• ETC. ETC.
12/7/19 USATODAY
JOEL PETT

How do we demonstrate the precautionary principle in our day-to-day decision making?

How does it apply to policy-makers' decisions in:
- food safety?
- medicine?
- genetics and bioethics?
- economics?

BioEthics Education Project:
http://www.beep.ac.uk

Try some of these resources:
Environmental Ethics

What value does the environment have? Which area? Farmland, rainforest, desert, meadow, river, mountain, tundra or sea? And to whom? Do we value it because it is useful or because it has a value in of itself?

These are some of the questions environmental ethicists hope to answer, and quickly, because the extent of the human population and its associated technology mean we are now able to cause more damage then ever before.

These pages address the following issues:

- Biodiversity
- Pollution
- Climate change
- Conservation

Poll

Does this rainforest flower have most value for you because:

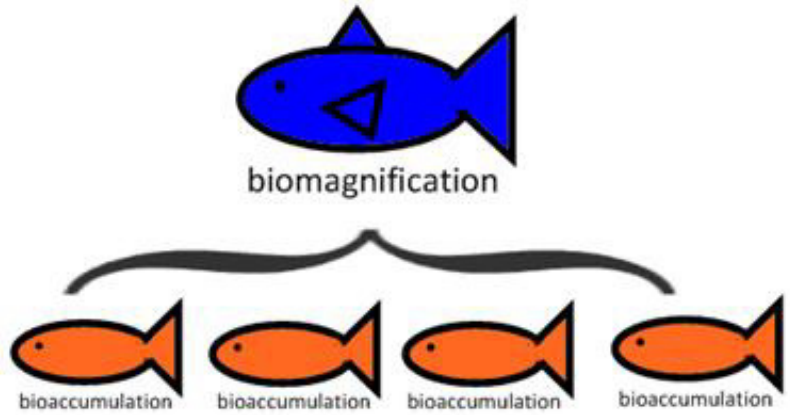
- all plants have value?
- it provides the ingredients for a drug used to treat childhood cancers?
- it is pretty?

Submit

More resources:

AAAS
ADVANCING SCIENCE, SERVING SOCIETY

http://www.aaas.org/news/press_room/climate_change/



The following slides are from the presentation

Impacts of Humans on Ecosystems

from

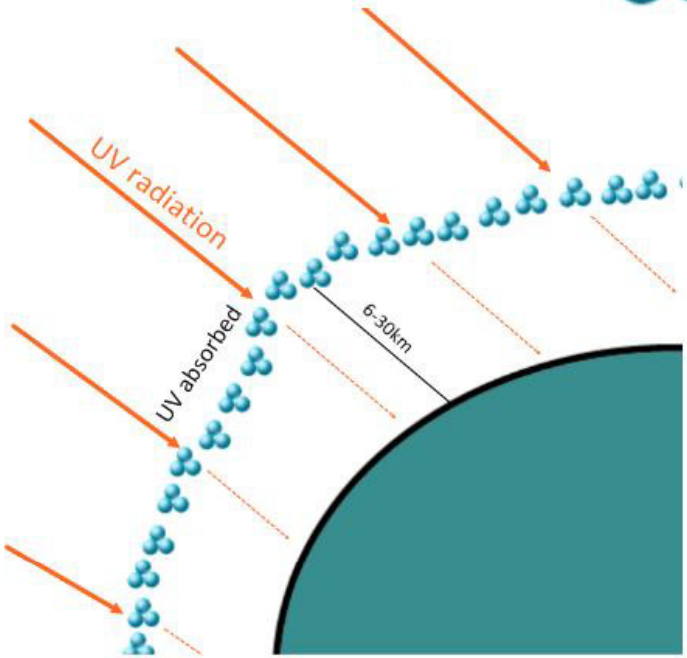
Option G: Ecology and Conservation

Ozone (O_3) in the stratosphere absorbs UV radiation.

The high concentration of ozone (O_3) in this layer absorbs over 93% of all UV radiation which reaches Earth.

The ozone can be depleted by chemical gases, including CFC's (chlorofluorocarbons). These aggregate over polar regions and the cold temperatures allow for the depletion of the ozone layer by splitting CFC molecules, using UV.

The result is more harmful UV radiation reaching the Earth's surface, where it can cause damage to living things and contribute to global warming.



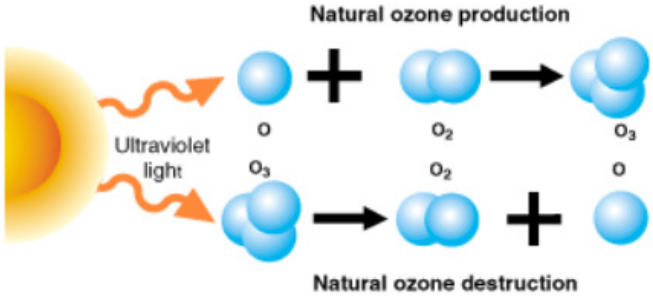
NASA explanation:

http://www.youtube.com/watch?v=qUfVMogIdr8

Ozone layer shielding the planet:

http://svs.gsfc.nasa.gov/vis/a000000/a000800/a000834/index.html

CFC's deplete the ozone layer



There is a natural balance of ozone creation and destruction due to UV radiation in the atmosphere. The ozone layer is maintained at safe levels.

When CFC's are released into the atmosphere, they speed the depletion of the ozone layer.

Source of all images:
http://www.bom.gov.au/lam/Students_Teachers/ozanim/ozoanim.shtml

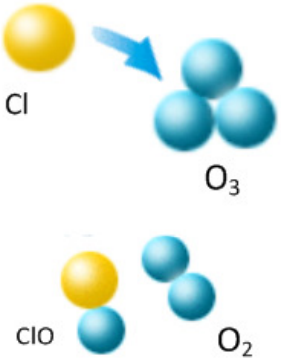
CFC molecule

1. UV radiation splits CFC molecules.

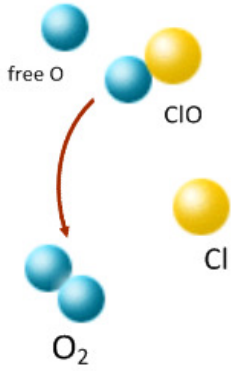
CFC molecule

2. This releases chlorine molecules.

Chlorine (Cl) Oxygen (O) Fluorine (F) Carbon (C)



3. Chlorine splits ozone molecules into O_2 and ClO (chlorine monoxide).

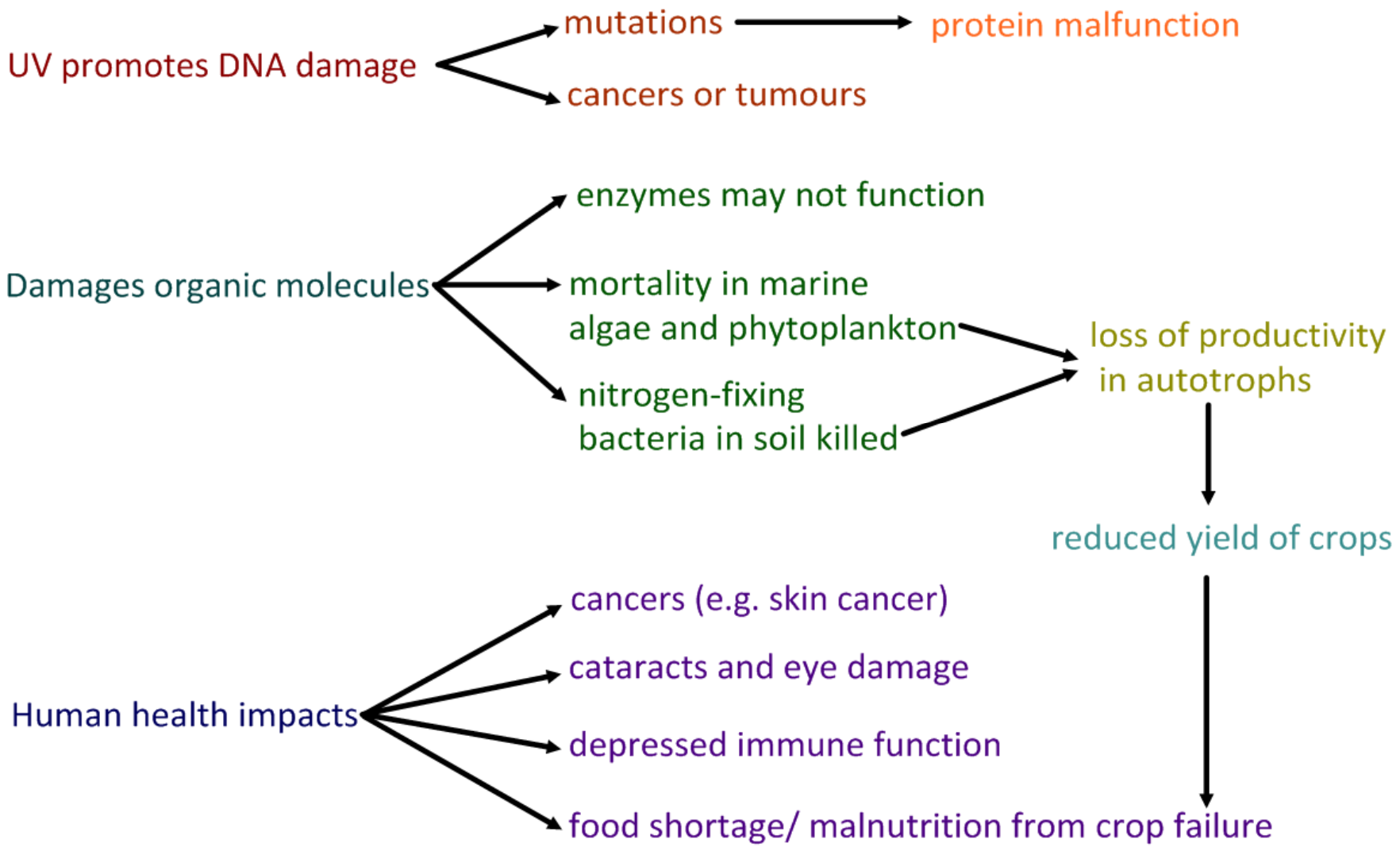


4. Chlorine then binds free oxygen atoms and is released.

5. Chlorine goes on to split more ozone molecules. It can split up to 100,000 molecules. At that rate, natural ozone production cannot compensate.

Extend Page

Elevated levels of UV are harmful to living organisms and biological productivity.



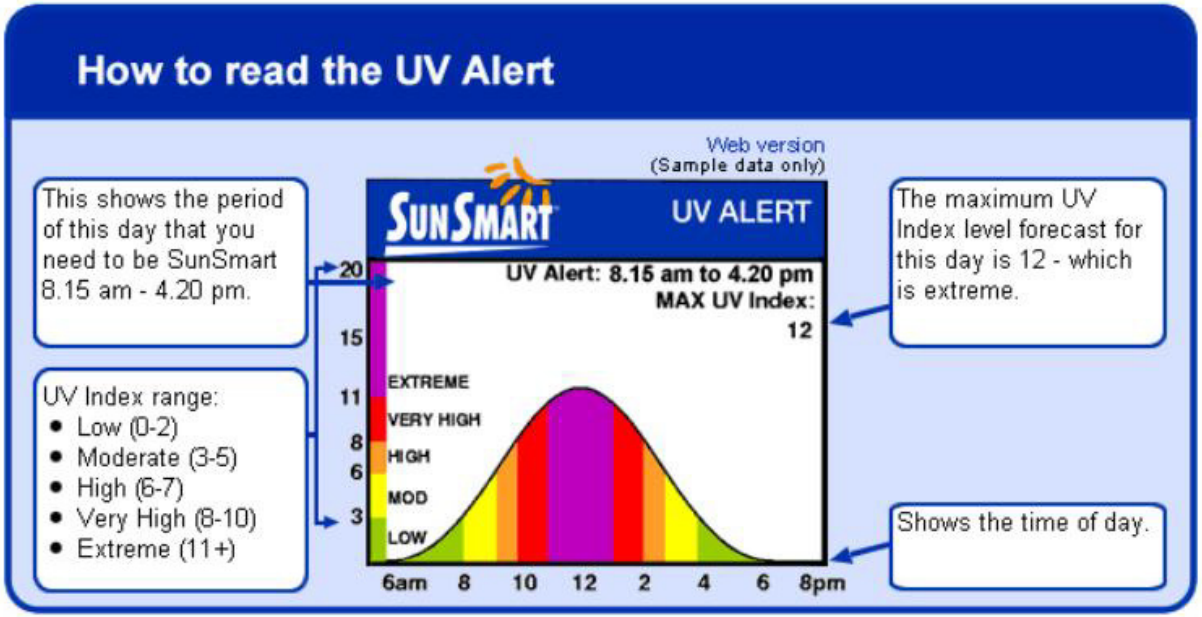
Stay safe in the sun!

From:

Australian Govern
Bureau of Meteorol

http://www.bom.gov.au/info/about_uv.sht

Check the UV Alerts (if they exist) for your area.



Protect yourself from harmful UV radia

Check for skin cancer:

http://64.143.176.9/library/healthguide/en-us/support/topic.asp?hwid=aa78799