Global environmental problems

Course module: Ecological geology

Lecturer: Mezhibor A.M., PhD

Global environmental problems for today

* Ozone depletion
* Climate warming
* Transboundary pollution
* Biodiversity reduction
* Marine pollution
* Drinking water supply

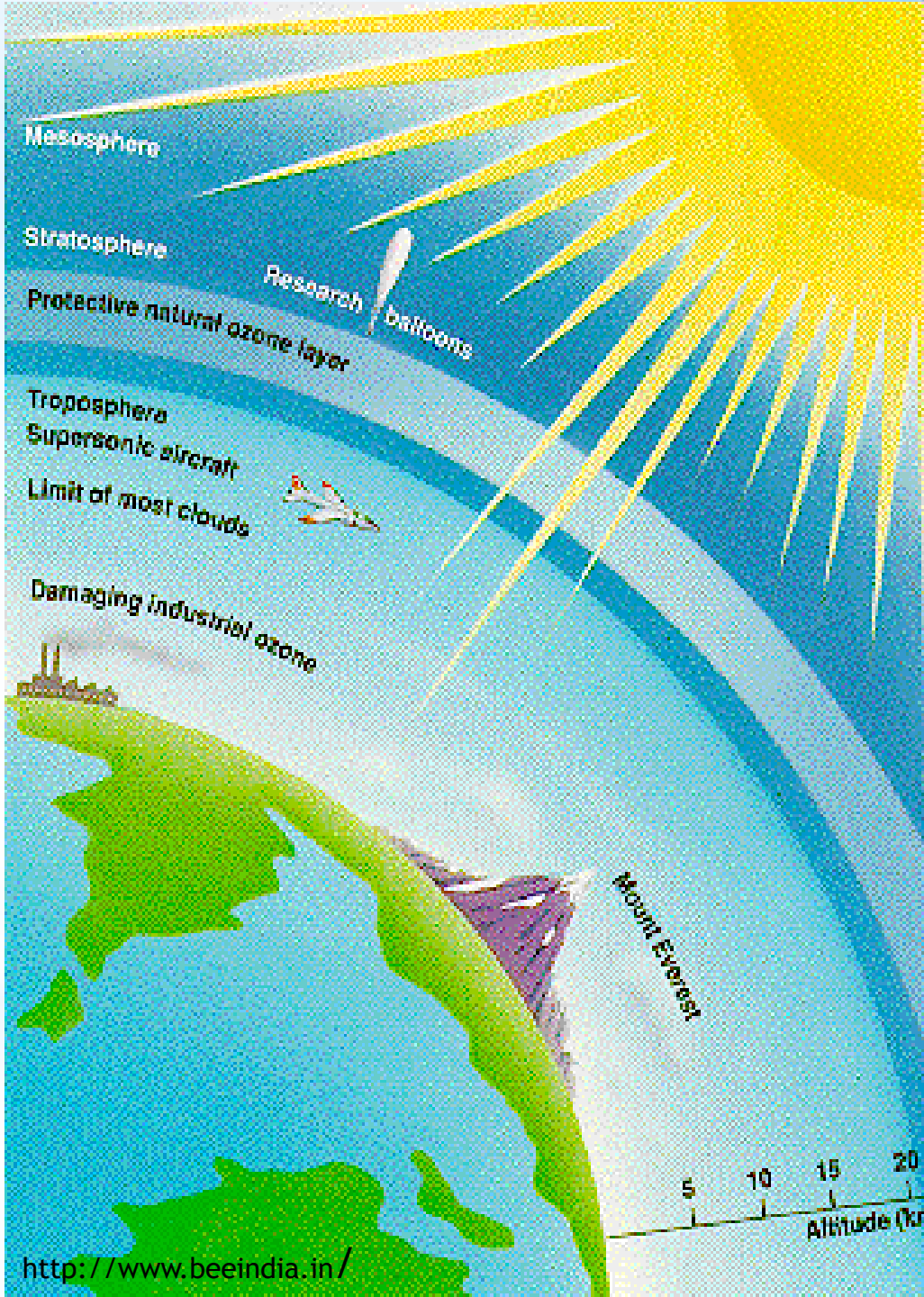
One of the most important characteristics of this environmental degradation is that it affects all mankind on a global scale without regard to any particular country, region, or race.

Ozone Layer Depletion

Earth's atmosphere is divided into three layers (troposphere, stratosphere and mesosphere).

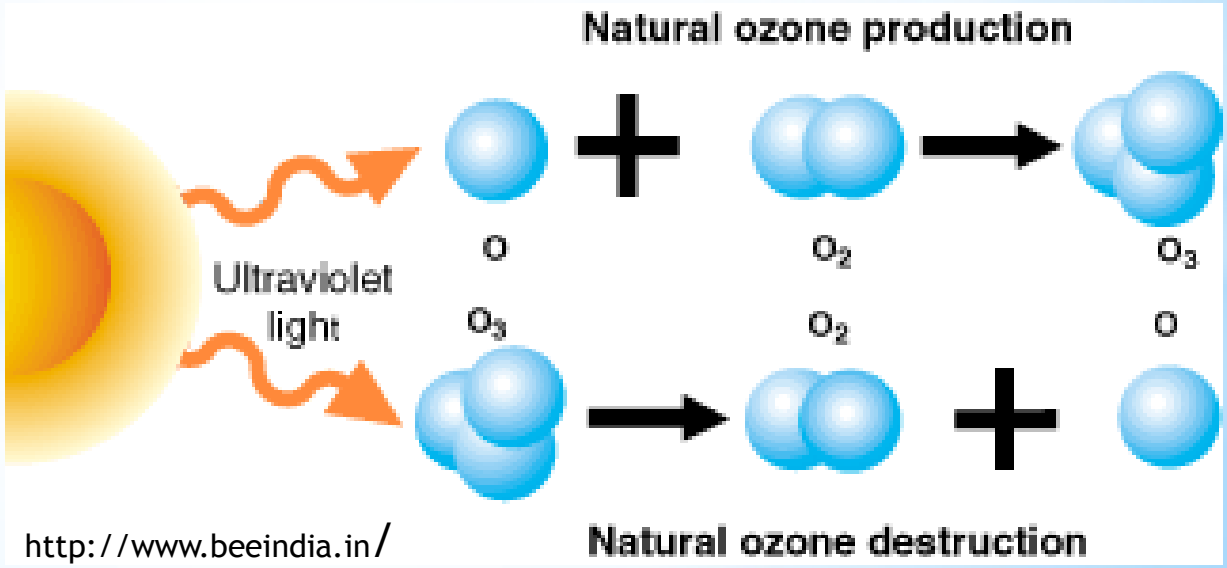
The stratosphere extends from 10 to 50 kms from the Earth's surface. This region is concentrated with light bluish ozone gas.

The ozone gas is made up of molecules each containing three atoms of oxygen (O^3). The ozone layer acts as an efficient filter for harmful solar Ultraviolet B (UV-B) rays.



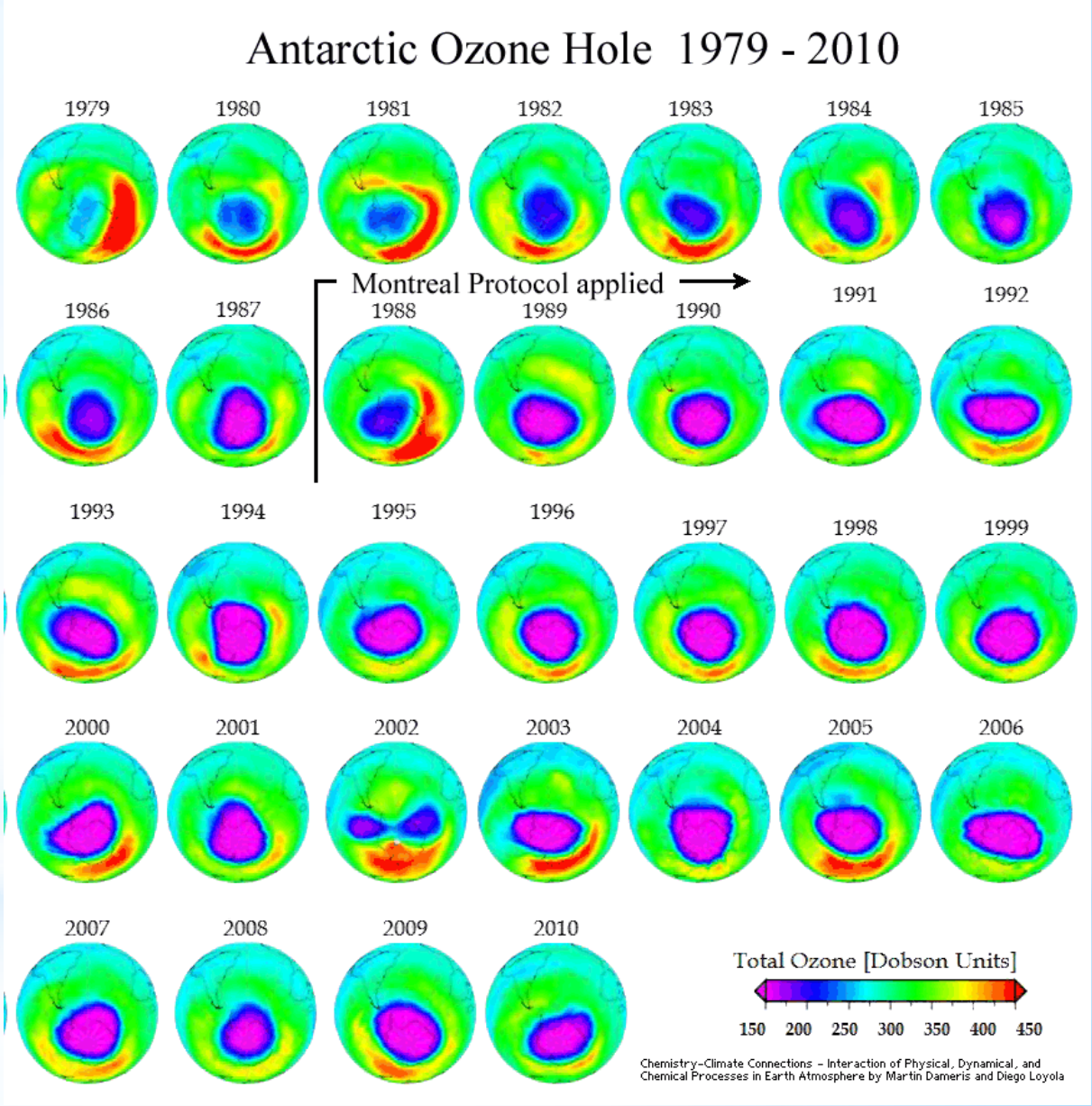
Ozone Production and Destruction Process

Ozone is produced and destroyed naturally in the atmosphere and until recently, this resulted in a well-balanced equilibrium. Ozone is formed when oxygen molecules absorb ultraviolet radiation with wavelengths less than 240 nm and is destroyed when it absorbs ultraviolet radiation with wavelengths greater than 290 nm.



http://www.beeindia.in/

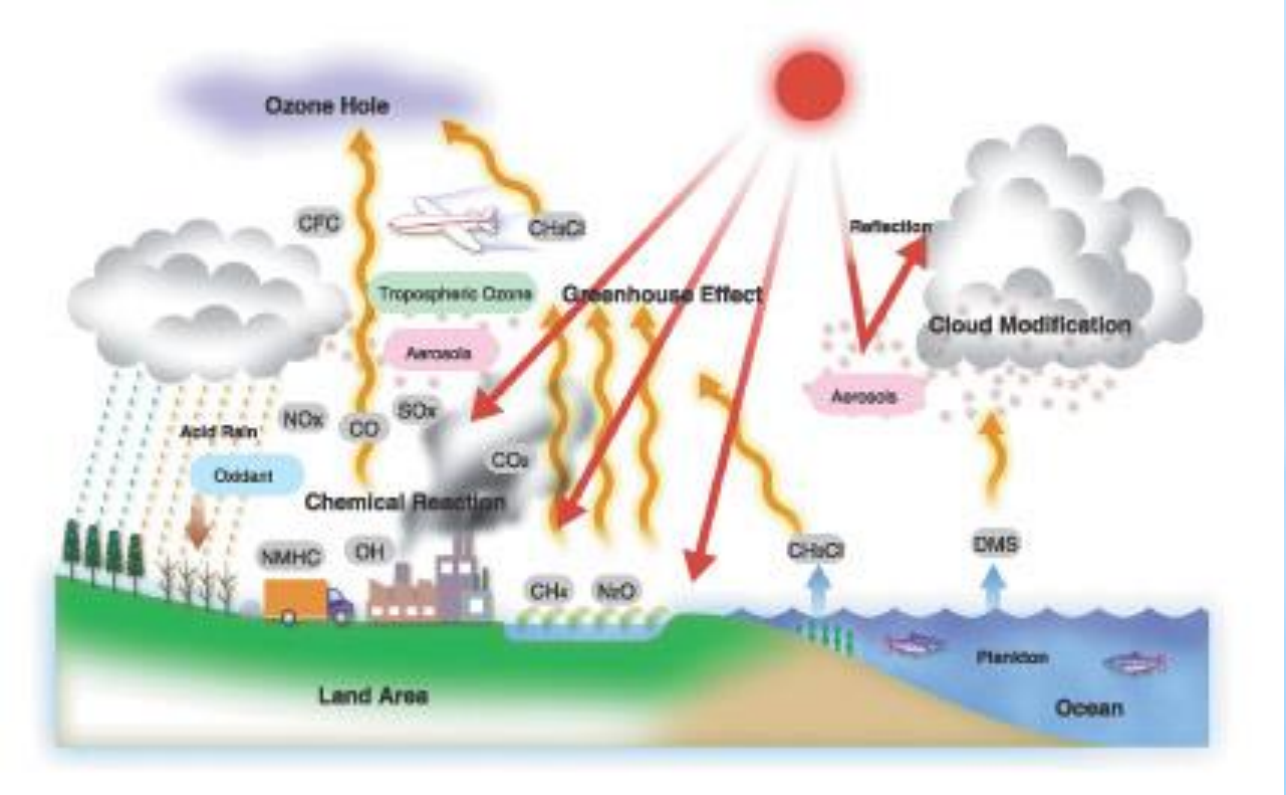
In recent years, scientists have measured a seasonal thinning of the ozone layer primarily at the South Pole. This phenomenon is being called the ozone hole.



http://www.rockyhigh66.org/stuff/ozone_hole_2010.png

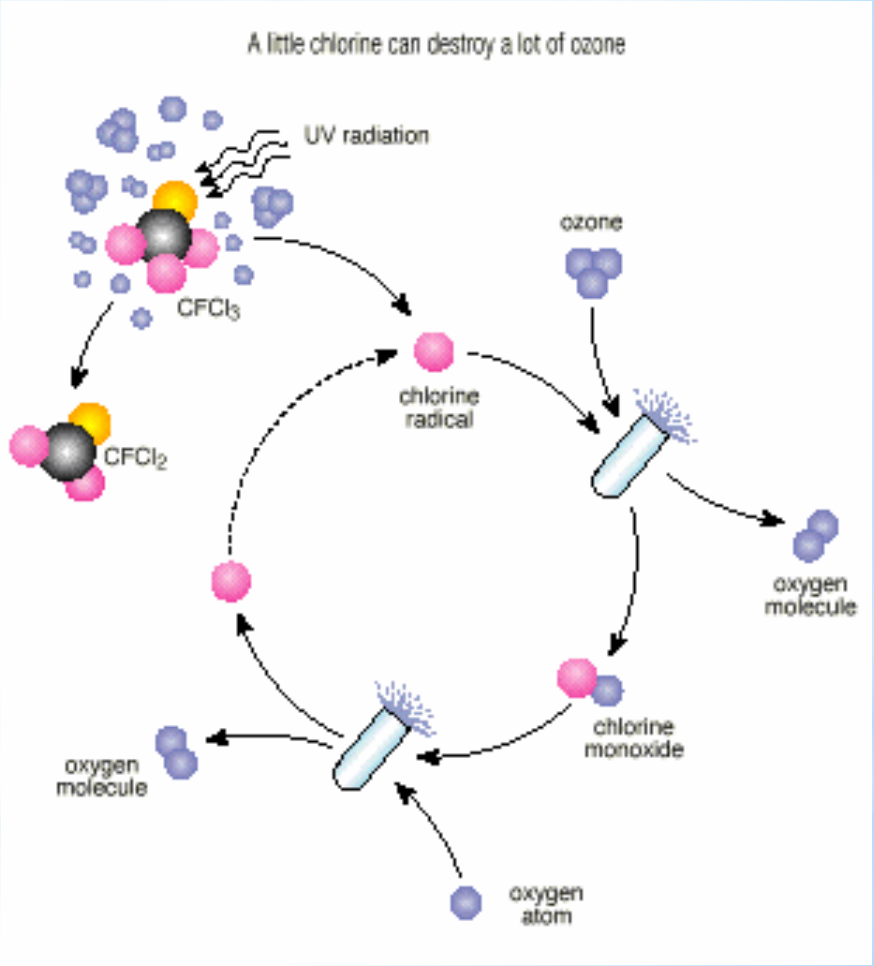
Ozone Depletion Process

* Ozone is highly reactive and easily broken down by man-made chlorine and bromine compounds. These compounds are found to be most responsible for most of ozone layer depletion.
* The ozone depletion process begins when CFCs (used in refrigerator and air conditioners) and other ozone-depleting substances (ODS) are emitted into the atmosphere. Winds efficiently mix and evenly distribute the ODS in the troposphere. These ODS compounds do not dissolve in rain, are extremely stable, and have a long life span. After several years, they reach the stratosphere by diffusion.



Strong UV light breaks apart the ODS molecules. CFCs, HCFCs, carbon tetrachloride, methyl chloroform release chlorine atoms, and halons and methyl bromide release bromine atoms.

It is the chlorine and bromine atom that actually destroys ozone, not the intact ODS molecule. It is estimated that one chlorine atom can destroy from 10,000 to 100,000 ozone molecules before it is finally removed from the stratosphere.



http://www.noulanka.lk/Scientific_Scienc1.gif

Chemical equation is

$$CFCl^3 + UV\ Light \Longrightarrow CFCl^2 + Cl\ Cl + O^3 \Longrightarrow ClO + O^2\ ClO + O \Longrightarrow Cl + O^2$$

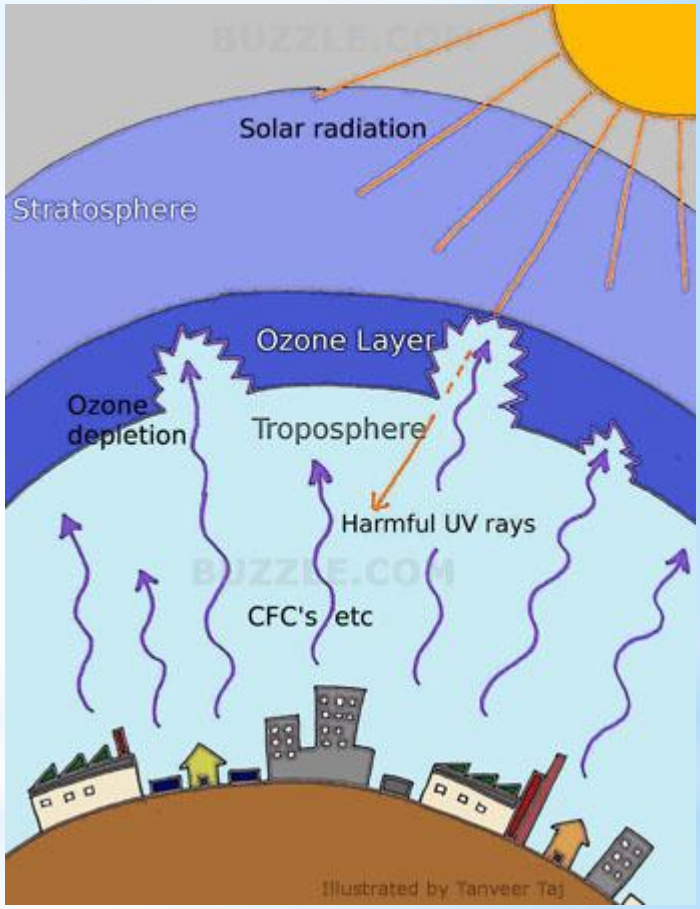
The free chlorine atom is then free to attack another ozone molecule

$$Cl + O^3 \Longrightarrow ClO + O^2\ ClO + O \Longrightarrow Cl + O^2$$

and again ...

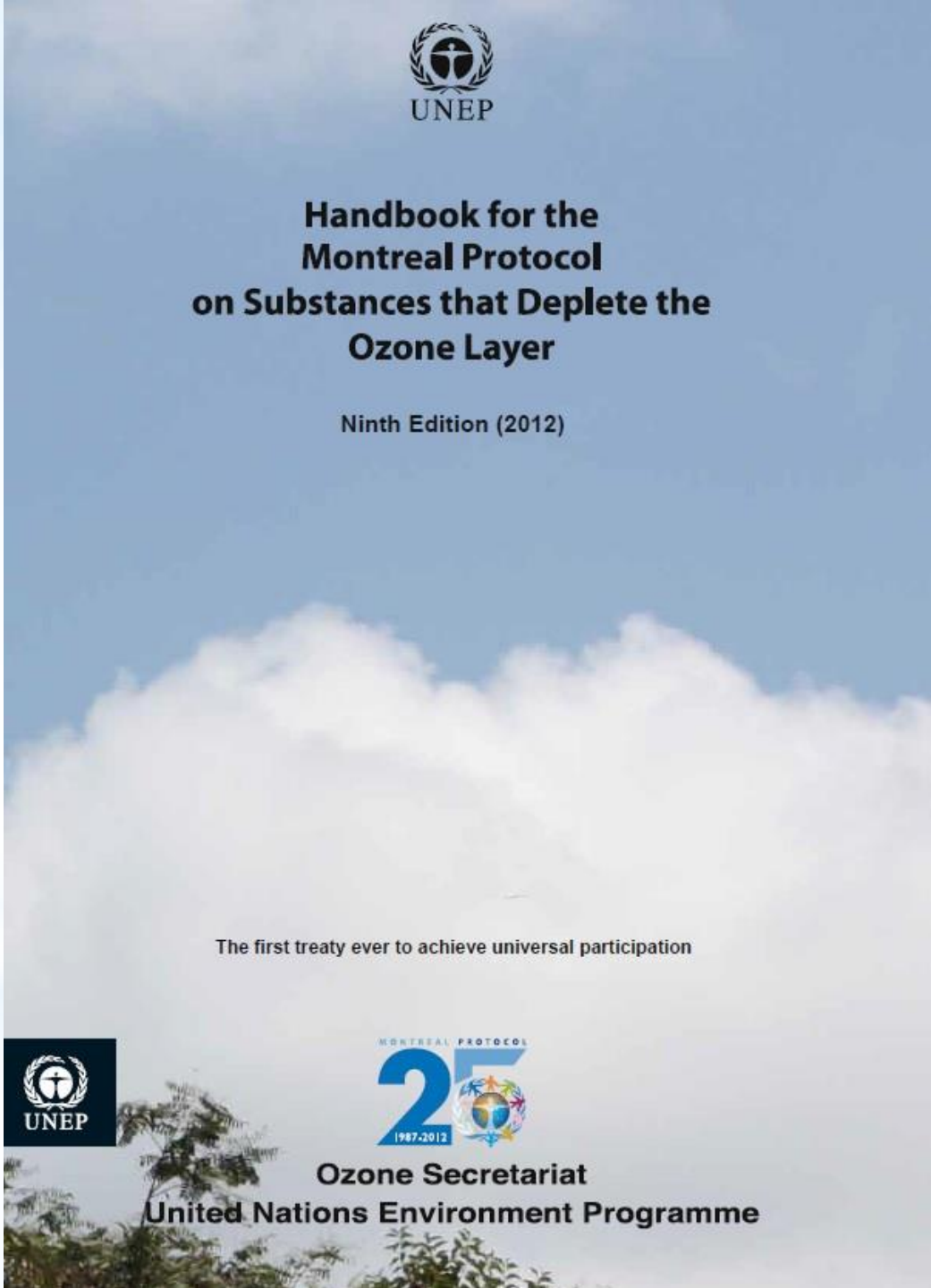
$$Cl + O^3 \Longrightarrow ClO + O^2\ ClO + O \Longrightarrow Cl + O^2$$

and again... for thousands of times.



To reduce the production and consumption of ozone depleting substances in order to reduce their abundance in the atmosphere, and thereby protect the earth's fragile ozone Layer, the Montreal Protocol on Substances that Deplete the Ozone Layer was designed.

The original Montreal Protocol was agreed on 16 September 1987 and entered into force on 1 January 1989.



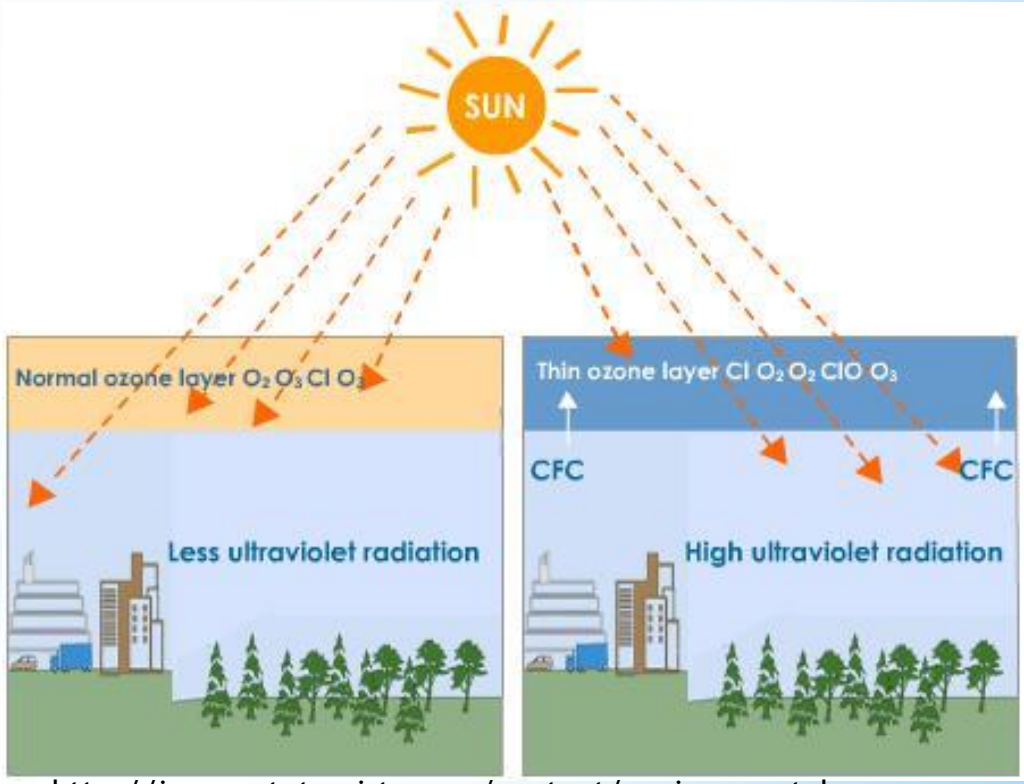
Effects of Ozone Layer Depletion

* **Effects on Human and Animal Health:**

Increased penetration of solar UV-B (middle-wave) radiation is likely to have high impact on human health with potential risks of eye diseases, skin cancer and infectious diseases.

* **Effects on Terrestrial Plants:**

Increased radiation is likely to change species composition thus altering the bio-diversity in different ecosystems.



http://images.tutorvista.com/content/environmental-changes/impact-of-ozone-depletion.jpeg

* Effects on Aquatic Ecosystems:

High levels of radiation exposure in tropics and subtropics may affect the distribution of phytoplanktons, which form the foundation of aquatic food webs. It can also cause damage to early development stages of fish, shrimp, crab, amphibians and other animals, the most severe effects being decreased reproductive capacity and impaired larval development.

* Effects on Bio-geo-chemical Cycles:

Increased solar UV radiation could affect terrestrial and aquatic bio-geo-chemical cycles thus altering both sources and sinks of greenhouse and important trace gases, e.g. carbon dioxide (CO^2), carbon monoxide (CO), carbonyl sulfide (COS), etc. These changes would contribute to biosphere-atmosphere feedbacks responsible for the atmosphere build-up of these greenhouse gases.

* Effects on Air Quality:

Reduction of stratospheric ozone and increased penetration of UV-B radiation result in higher photo dissociation rates of key trace gases that control the chemical reactivity of the troposphere. This can increase both production and destruction of ozone and related oxidants such as hydrogen peroxide, which are known to have adverse effects on human health, terrestrial plants and outdoor materials.

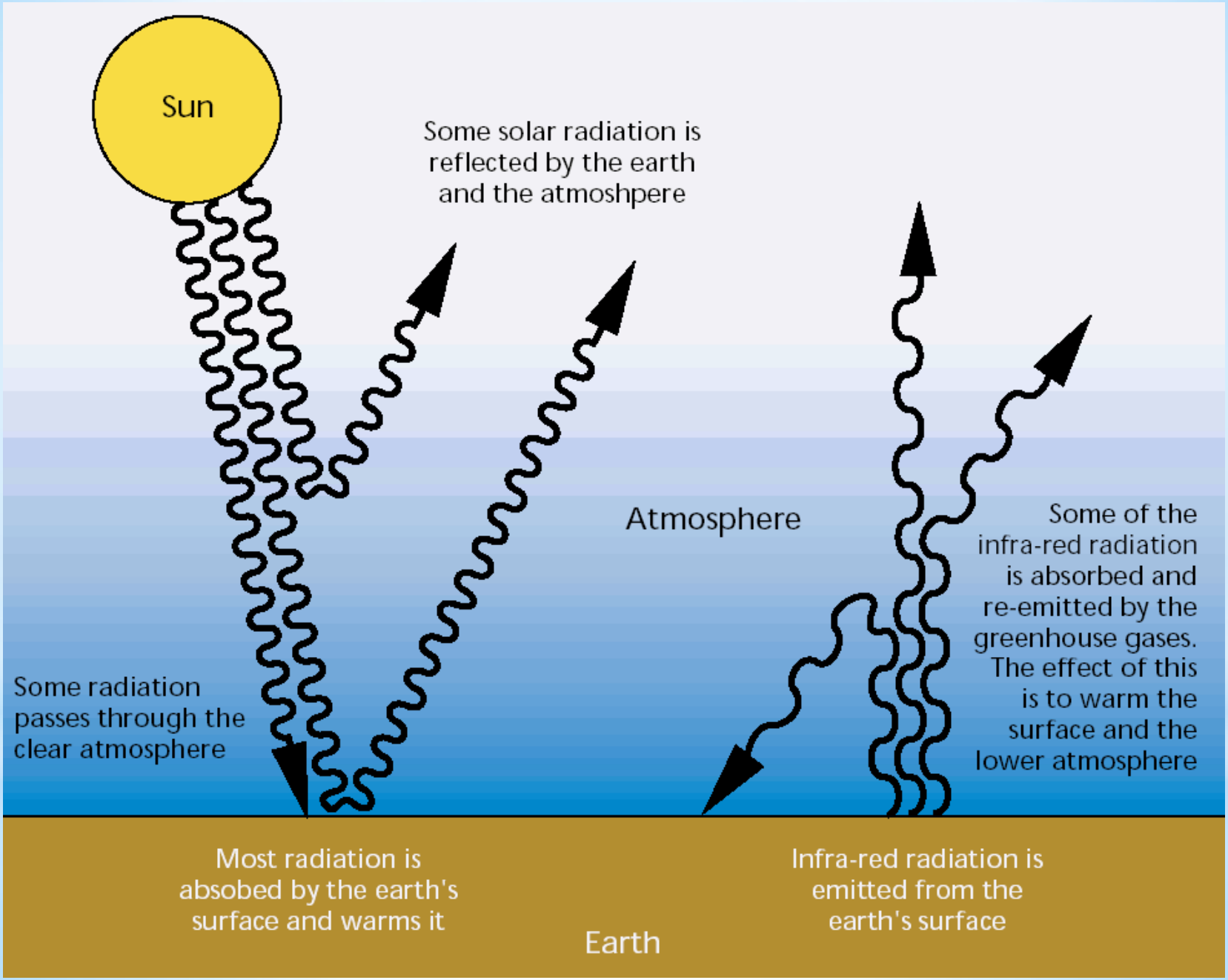
* Effects of Ozone Layer Depletion

Global warming

* 1896 - the Swedish scientist Svante Arrhenius had predicted that human activities would interfere with the way the sun interacts with the earth, resulting in global warming and climate change.
* His prediction has become true and climate change is now disrupting global environmental stability. The last few decades have seen many treaties, conventions, and protocols for the cause of global environmental protection.

http://www.whoi.edu/cms/images/globalwarming_main_198896.jpe

* Before the Industrial Revolution, human activities released very few gases into the atmosphere and all climate changes happened naturally. After the Industrial Revolution, through fossil fuel combustion, changing agricultural practices and deforestation, the natural composition of gases in the atmosphere is getting affected and climate and environment began to alter significantly.
* Over the last 100 years, it was found out that the earth is getting warmer and warmer, unlike previous 8000 years when temperatures have been relatively constant. The present temperature is 0.3 - 0.6 ^{o}C warmer than it was 100 years ago.



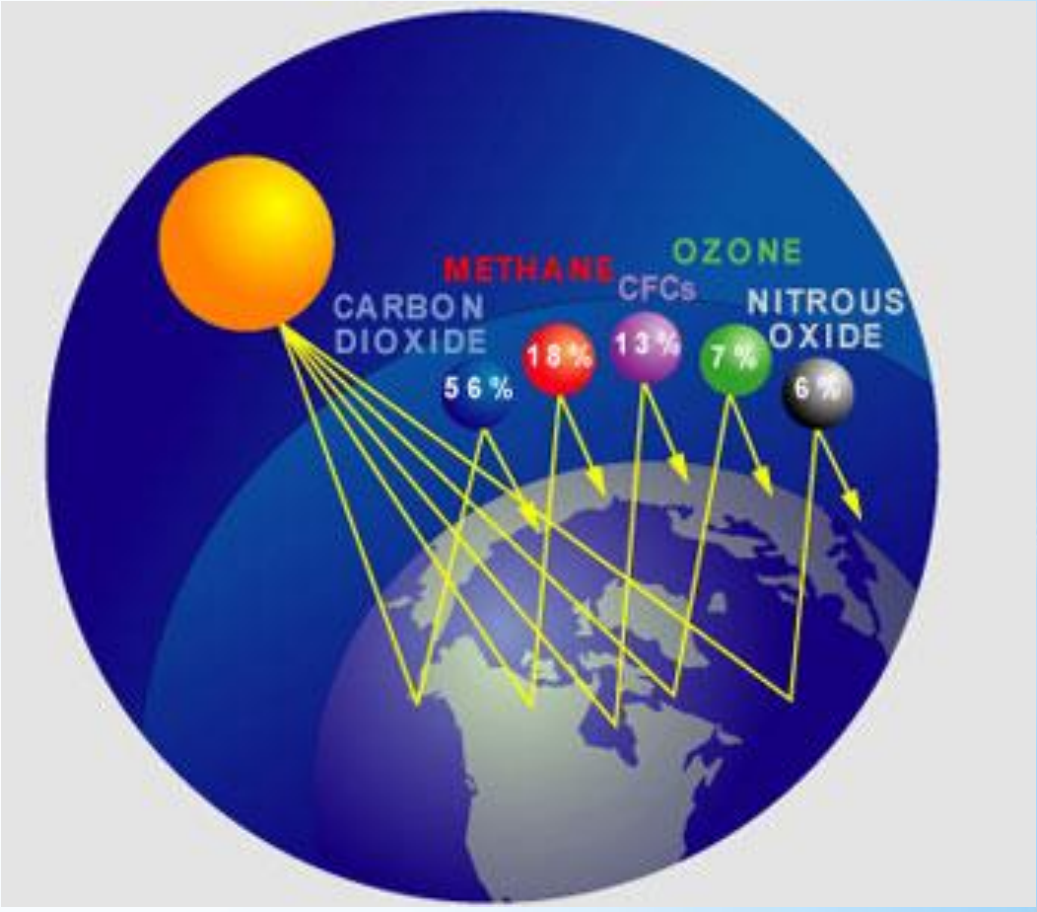
http://www.greenhouse.unimelb.edu.au/images_hr/GHGeffect.gif

* The key greenhouse gases (GHG) causing global warming is carbon dioxide.
* CFC's, even though they exist in very small quantities, are significant contributors to global warming.

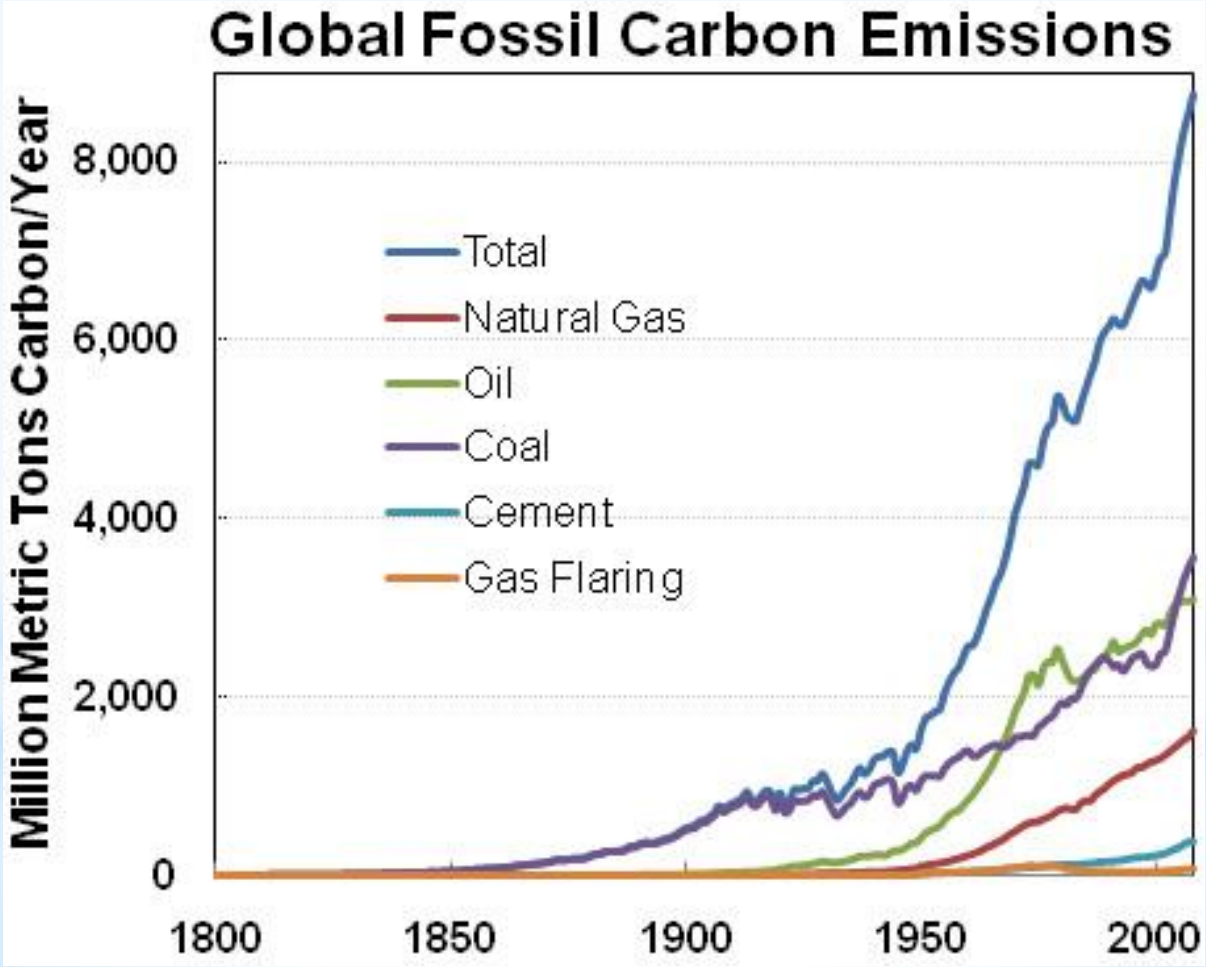
Carbon dioxide has two major anthropogenic (human-caused) sources:

- the combustion of fossil fuels
- and changes in land use.

Net releases of carbon dioxide from these two sources are believed to be contributing to the rapid rise in atmospheric concentrations since Industrial Revolution.



Approximately 80 percent of all anthropogenic carbon dioxide emissions currently come from fossil fuel combustion. Thus, world energy use has emerged at the center of the climate change debate.



http://www.netl.doe.gov/research/coal/carbon-capture/drivers

Sources of Greenhouse Gases

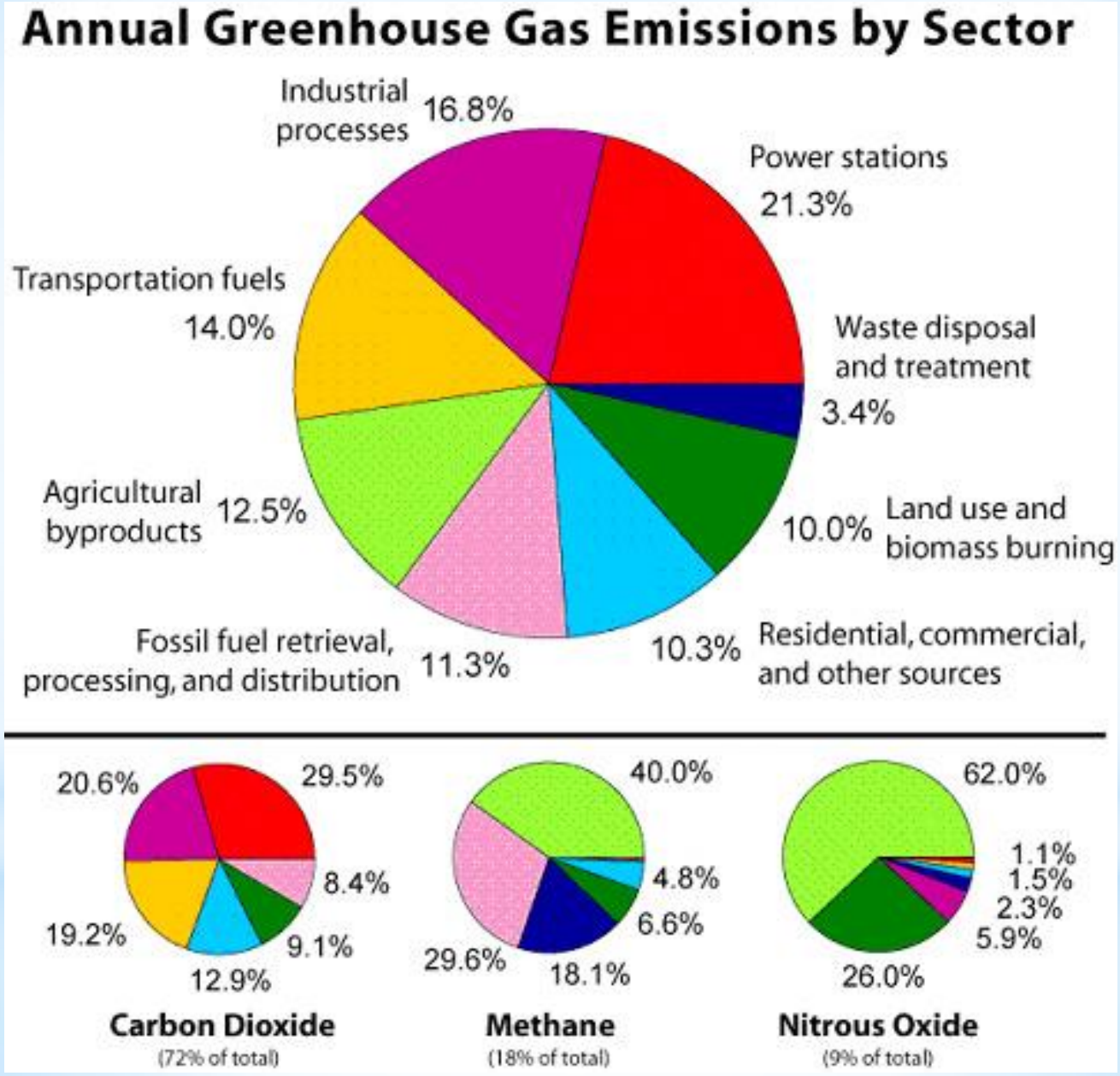
* Some greenhouse gases occur naturally in the atmosphere, while others result from human activities.

Naturally occurring greenhouse gases:

- water vapor,
- carbon dioxide,
- methane,
- nitrous oxide,
- and ozone.

Certain human activities add to the levels of most of these naturally occurring gases.

* Carbon dioxide is released to the atmosphere when solid waste, fossil fuels (oil, natural gas, and coal), and wood and wood products are burned.
* Methane is emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from the decomposition of organic wastes in municipal solid waste landfills, and the raising of livestock.
* Nitrous oxide is emitted during agricultural and industrial activities, as well as during combustion of solid waste and fossil fuels.
* Hydrofluorocarbons (HFCs) are very powerful greenhouse gases that are not naturally occurring are generated in a variety of industrial processes.



http://www.netl.doe.gov/research/coal/carbon-capture/drivers#six

Global Warming Potential

* Often, estimates of greenhouse gas emissions are presented in units of millions of metric tons of carbon equivalents (MMTCE), which weights each gas by its Global Warming Potential or GWP value.
* The following CO_2 equivalence factors were used to assess the GWP from air emissions.

CO_2 Equivalence Factors of Various substances (GWP, 100 yrs)

substance (in air)	CO_2 equivalence factor
1 kg CO_2	1 kg eq CO_2
1 kg CH_4	23 kg eq CO_2
1 kg N_2O	296 kg eq CO_2
1 kg CF_4	5700 kg eq CO_2
1 kg C_2F_6	11900 kg eq CO_2

Source: GIEC (2001)

Global Warming Potential of Primary Greenhouse Gases

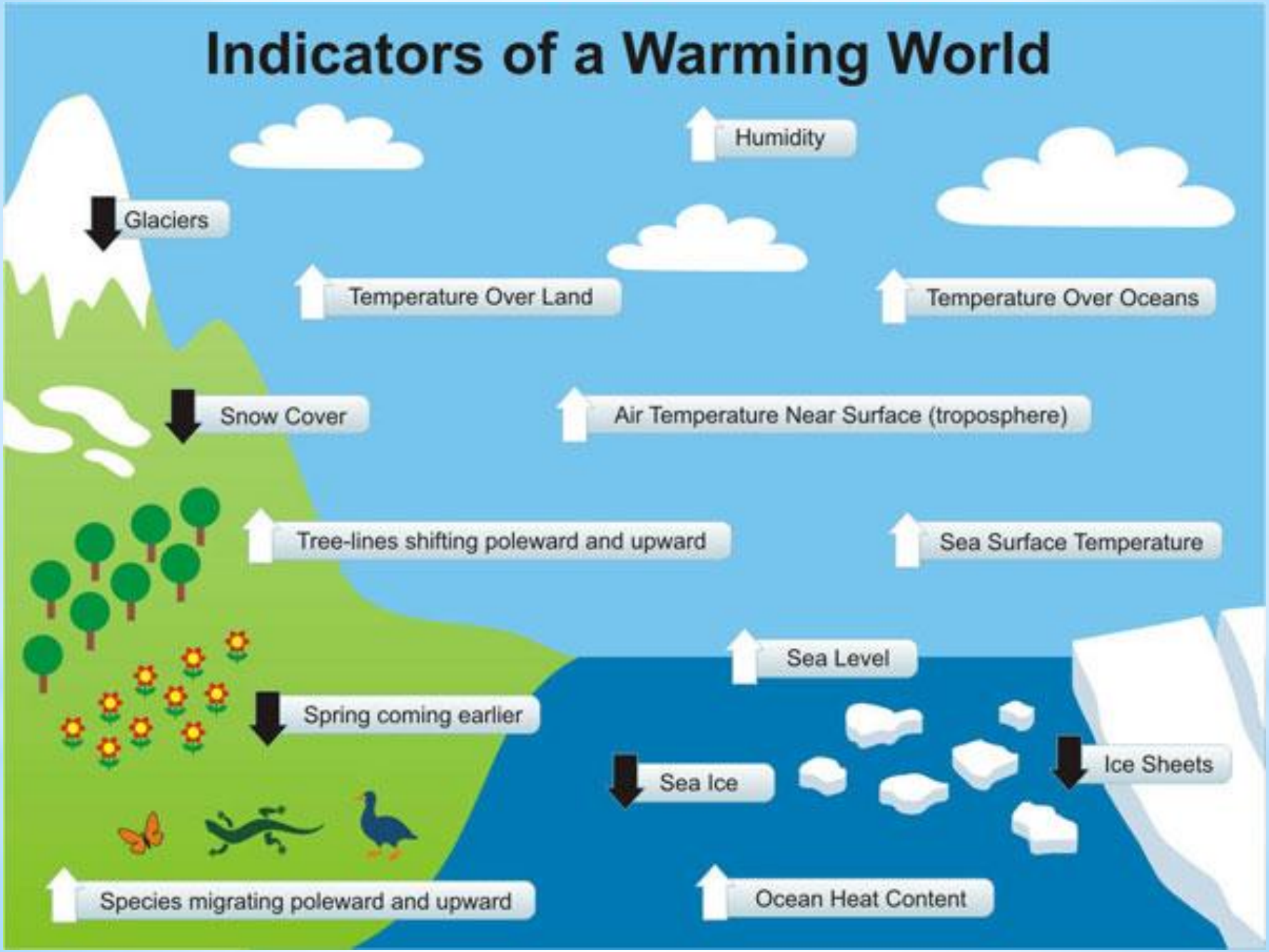
Greenhouse Gas	Chemical formula	Global Warming Potential [Time Horizon] 20 years	100 years
Carbon Dioxide	CO_2	1	1
Methane	CH_4	42-70	16-26
Nitrous Oxide	N_2O	280	310
Hydrofluorocarbons	HFCs	460 - 9,100	140-11,700
Perfluorocarbon	PFCs	4,400-6,200	6,500-23,900
Sulphur Hexafluoride	SF_6	16,300	23,900

http://www.netl.doe.gov/KeyIssues/climate_change2.html

Global-warming potential (GWP) is a relative measure of how much heat a greenhouse gas traps in the atmosphere compared to carbon dioxide. For example, the 20 year GWP of methane is 42-70, which means that each ton of methane introduced into the atmosphere will trap 42-70 times as much heat as each ton of carbon dioxide over the next 20 years. Variations in GWP over time reflect the decay/removal characteristics of GHGs in the atmosphere, which are often uncertain. Increasing GWP over time suggests that the gas decays or is removed-from the atmosphere more slowly than CO_2.

Source: World Coal Council

* Each greenhouse gas differs in its ability to absorb heat in the atmosphere. HFCs and PFCs are the most heat-absorbent. Methane traps over 21 times more heat per molecule than carbon dioxide, and nitrous oxide absorbs 270 times more heat per molecule than carbon dioxide. Conventionally, the GWP of carbon dioxide, measured across all time horizons, is 1.
* Other greenhouse gases have much higher GWPs than carbon dioxide, but because their concentration in the atmosphere is much lower, carbon dioxide is still the most important greenhouse gas, contributing about 60% to the enhancement of the greenhouse effect.



http://www.solarpowernotes.com/what-is-global-warming.html#.VRUK9OHsSpA

Consequences of global warming

Some impacts from increasing temperatures are already happening.

* Ice is melting worldwide, especially at the Earth's poles. This includes mountain glaciers, ice sheets covering West Antarctica and Greenland, and Arctic sea ice.
* The numbers of Adélie penguins on Antarctica have fallen from 32,000 breeding pairs to 11,000 in 30 years (according to Bill Fraser)
* Sea level rise became faster over the last century.
* Some butterflies, foxes, and alpine plants have moved farther north or to higher, cooler areas.
* Precipitation (rain and snowfall) has increased across the globe, on average.
* In Alaska, thanks to 20 years of warm summers, the insects have chewed up 4 million acres of spruce trees.

http://i2.cdn.turner.com/cnn/2009/images/07/29/gall.iceberg.jpg

http://eslblogcafe.com/sjc/poycha30608/files/2014/11/penguins.jpg

Other effects could happen later this century, if warming continues.

* Sea levels are expected to rise between 18 and 59 cm by the end of the century, and continued melting at the poles could add between 10 to 20 cm.
* Hurricanes and other storms are likely to become stronger.
* Species that depend on one another may become out of sync.
* Floods and droughts will become more common.
* Less fresh water will be available.
* Some diseases will spread, such as malaria carried by mosquitoes.
* Ecosystems will change — some species will move farther north or become more successful; others won't be able to move and could become extinct.

Source for climate information: IPCC, 2007



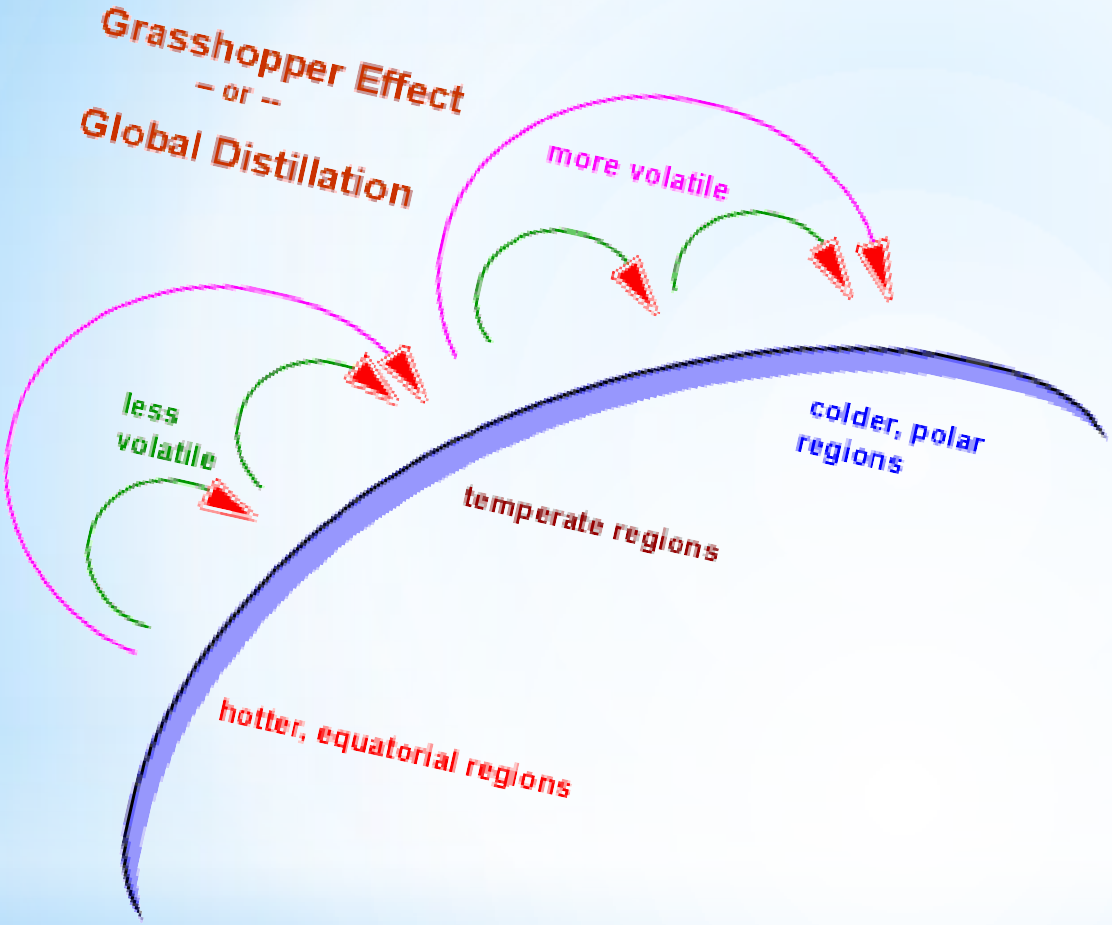
The Kyoto Protocol

* Negotiations on the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) were completed December 11, 1997, committing the industrialized nations to specify, legally binding reductions in emissions of six greenhouse gases. The 6 major greenhouse gases covered by the protocol are carbon dioxide (CO^2), methane (CH^4), nitrous oxide (N^2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur xafluoride (SF^6).


Video: http://www.solarpowernotes.com/what-is-global-warming.html#.VRUK9OHsSp
http://dailygreenpost.com/wp-content/uploads/51535927d1c6ddacf65935ba7b519ee9cdb06_640.jpg

Transboundary Pollution

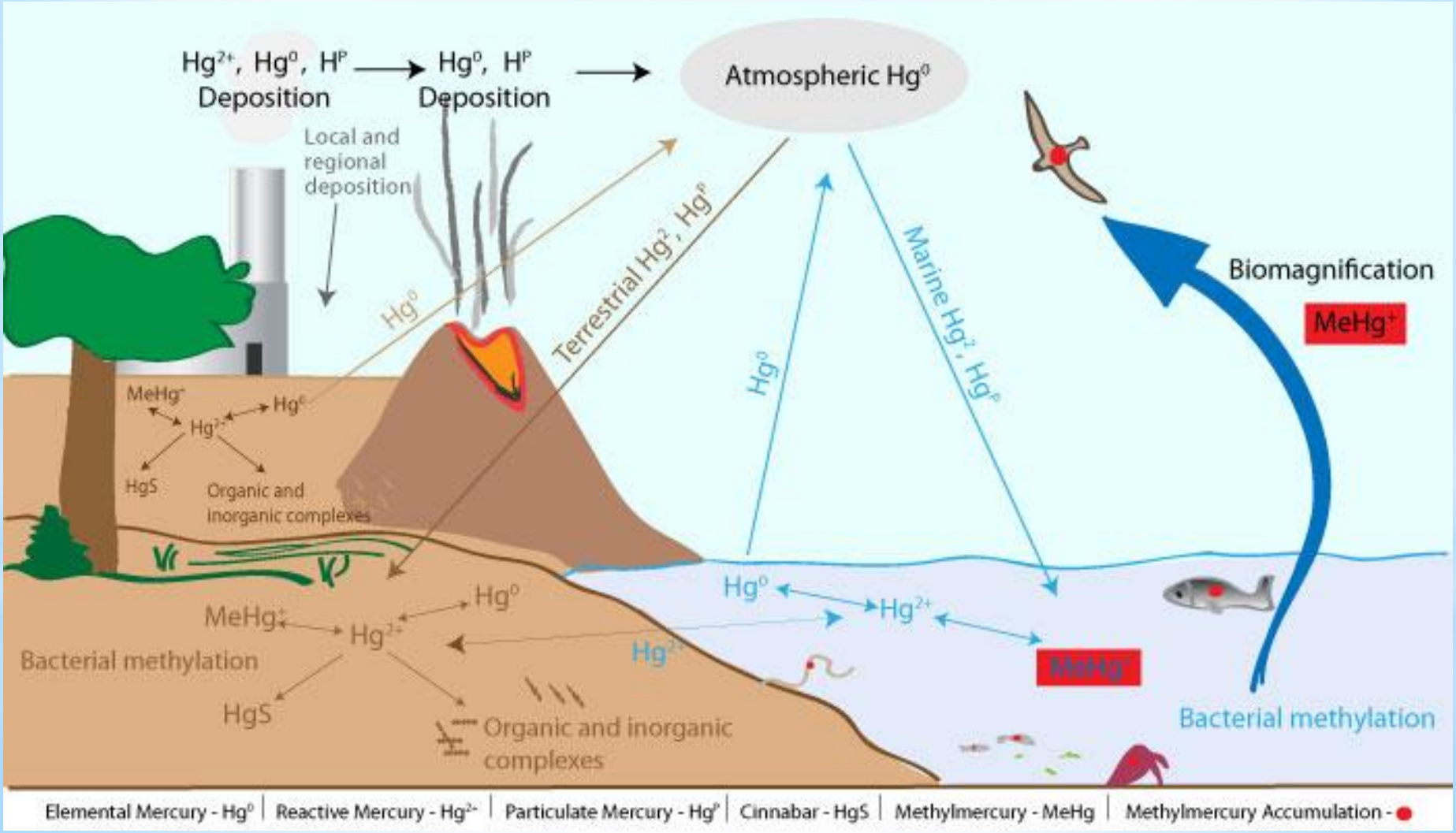
* Transboundary pollution is the pollution that originates in one country but is able to cause damage in another country's environment, by crossing borders through pathways like water or air.
* Pollution can be transported across hundreds and even thousands of kilometers. The incredible distances that pollution can spread means that it is not contained within the boundaries of any single nation.
* One of the problems with transboundary pollution is that can carry pollution away from a heavy emitter and deposit it onto a nation whose emissions are relatively low.
* Due to the fact that 'All things connect', the heavy pollution that is evident in the developed world also becomes evident in remote areas.



The “grasshopper effect” is the name used to describe how the pollutants are able to travel: toxic pollutants released thousands of miles to the south evaporate in the warm climate. They then ride the winds until they reach the cold air of the Arctic, where they eventually fall to the earth.

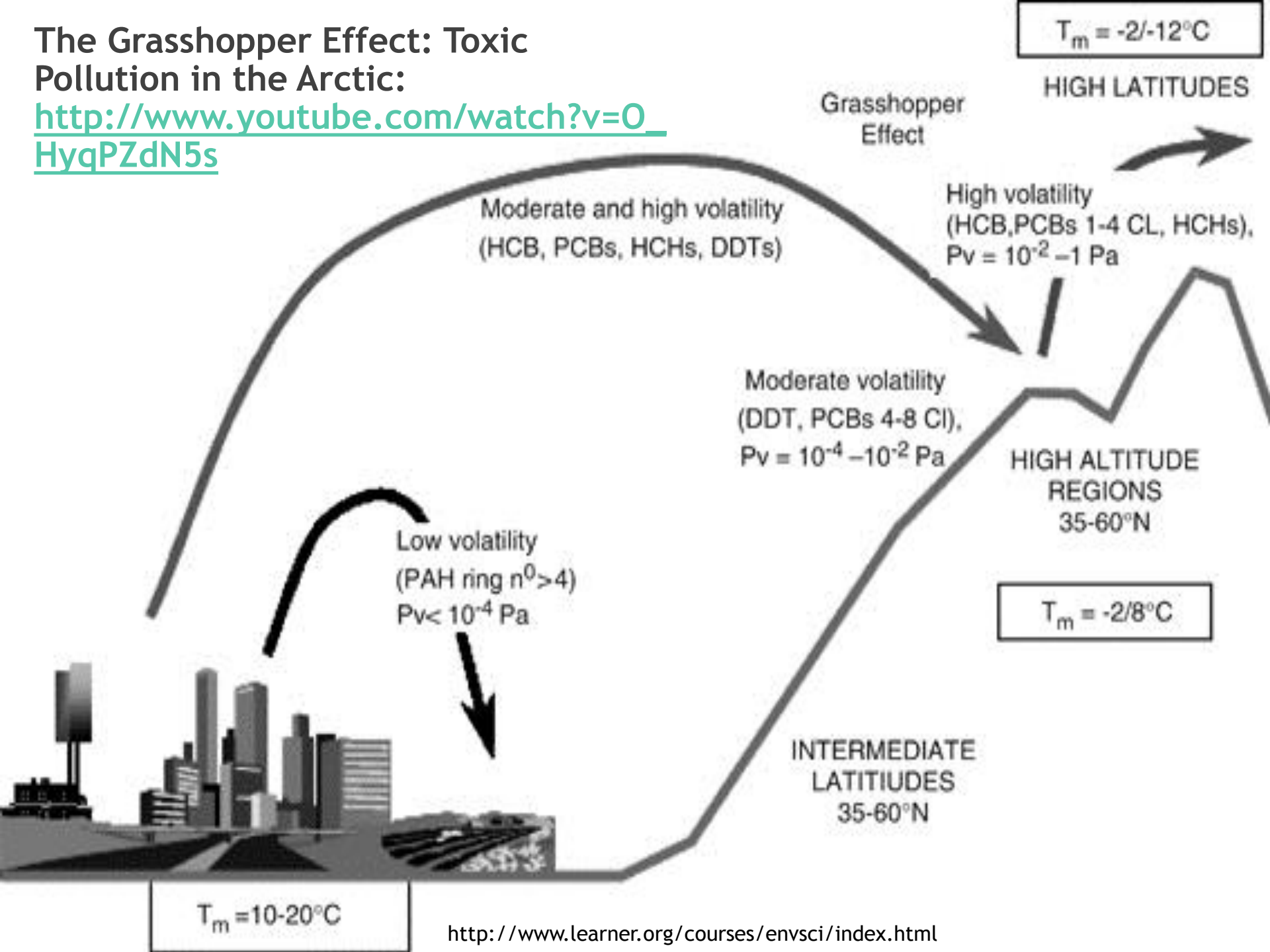
http://www.sseas.uconn.edu/RESEARCHunit2.htm

Mercury (Hg) migration



The Grasshopper Effect: Toxic Pollution in the Arctic:

http://www.youtube.com/watch?v=O_HyqPZdN5s



http://www.learner.org/courses/envsci/index.html

Biodiversity refers to the variety of life on earth, and its biological diversity. The number of species of plants, animals, micro organisms, the enormous diversity of genes in these species, the different ecosystems on the planet, such as deserts, rainforests and coral reefs are all a part of a biologically diverse earth.

Biodiversity actually boosts ecosystem productivity where each species, no matter how small, all have an important role to play and that it is in this combination that enables the ecosystem to possess the ability to prevent and recover from a variety of disasters.

http://www.greenrooftechnology.com/biodiversity

Biodiversity reduction

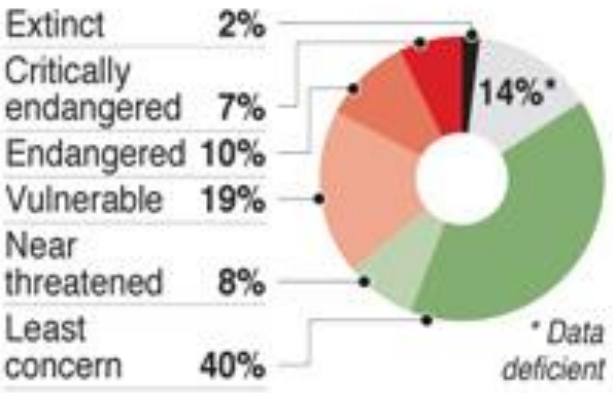
GLOBAL BIODIVERSITY

Natural systems that support economies, lives and livelihoods across the planet are at risk of rapid degradation and collapse. Natural habitats in most parts of the world are shrinking, plant and animal populations face constant threat

2010 International Year of Biodiversity

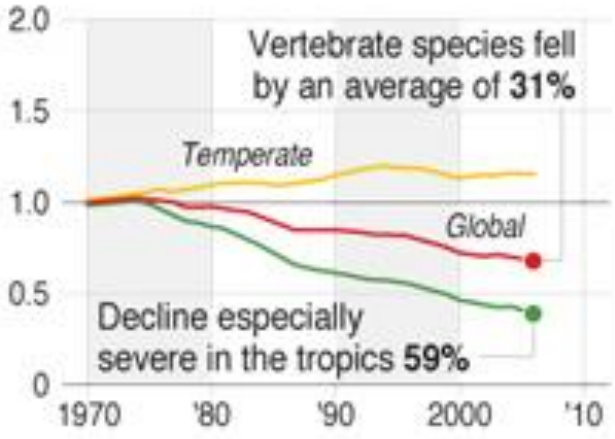
SPECIES UNDER THREAT

As of 2009, 36% of 47,677 species are considered threatend with extinction



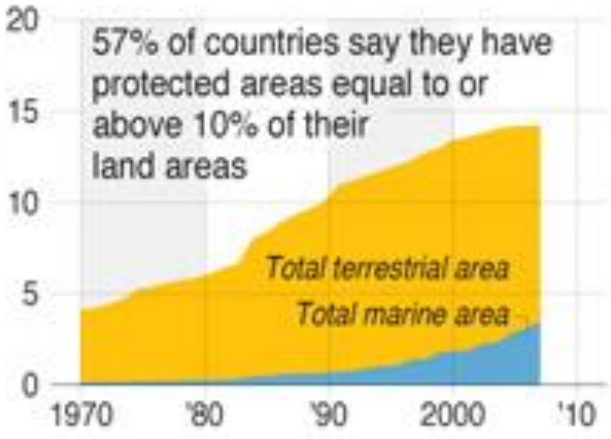
LIVING PLANET INDEX

Global wild vertebrate species



PROTECTED AREAS

Nationally designated in million sq. km



REUTERS

http://www.savingspecies.org/2012/5-awesome-biodiversity-infographics/#/

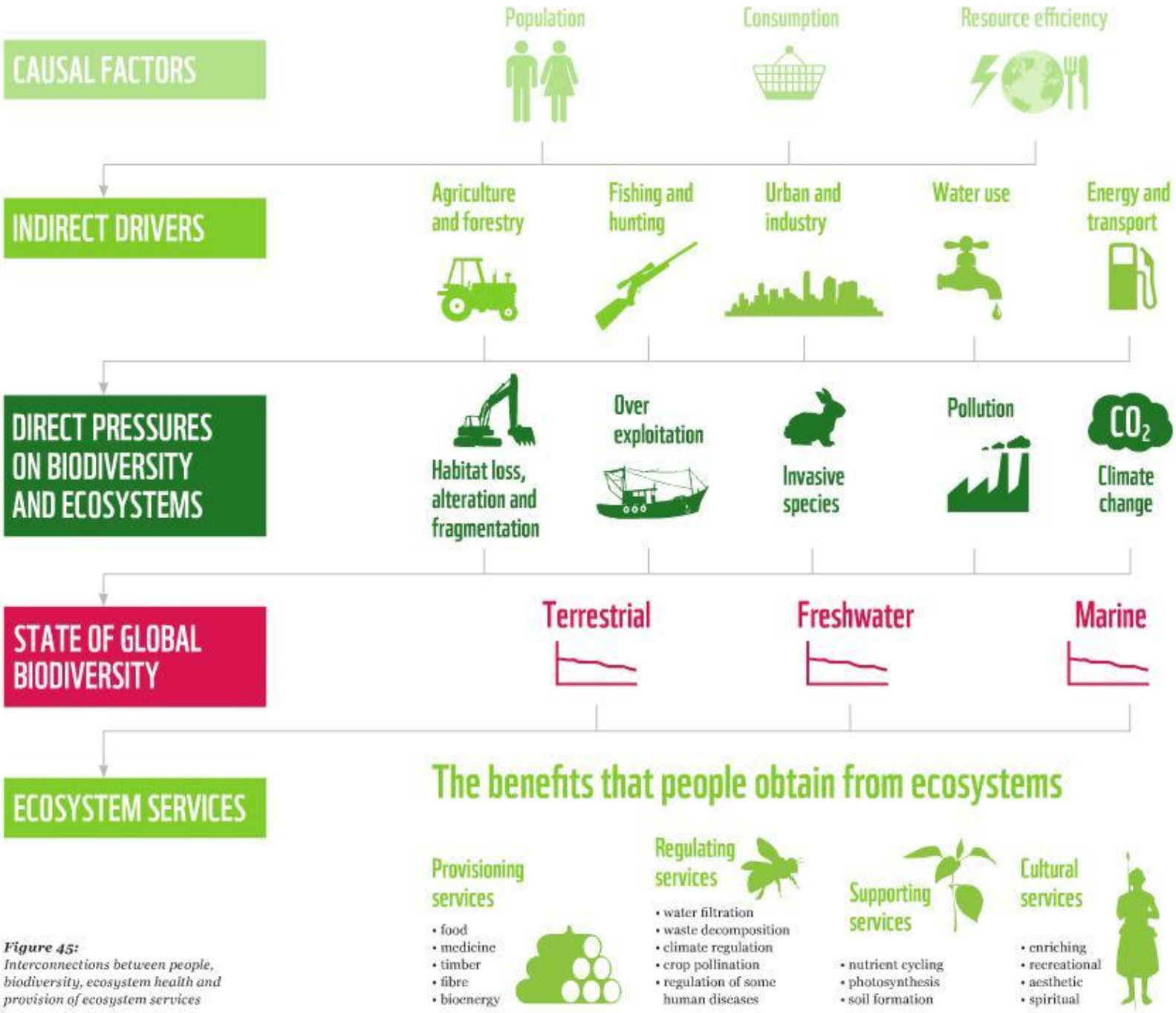
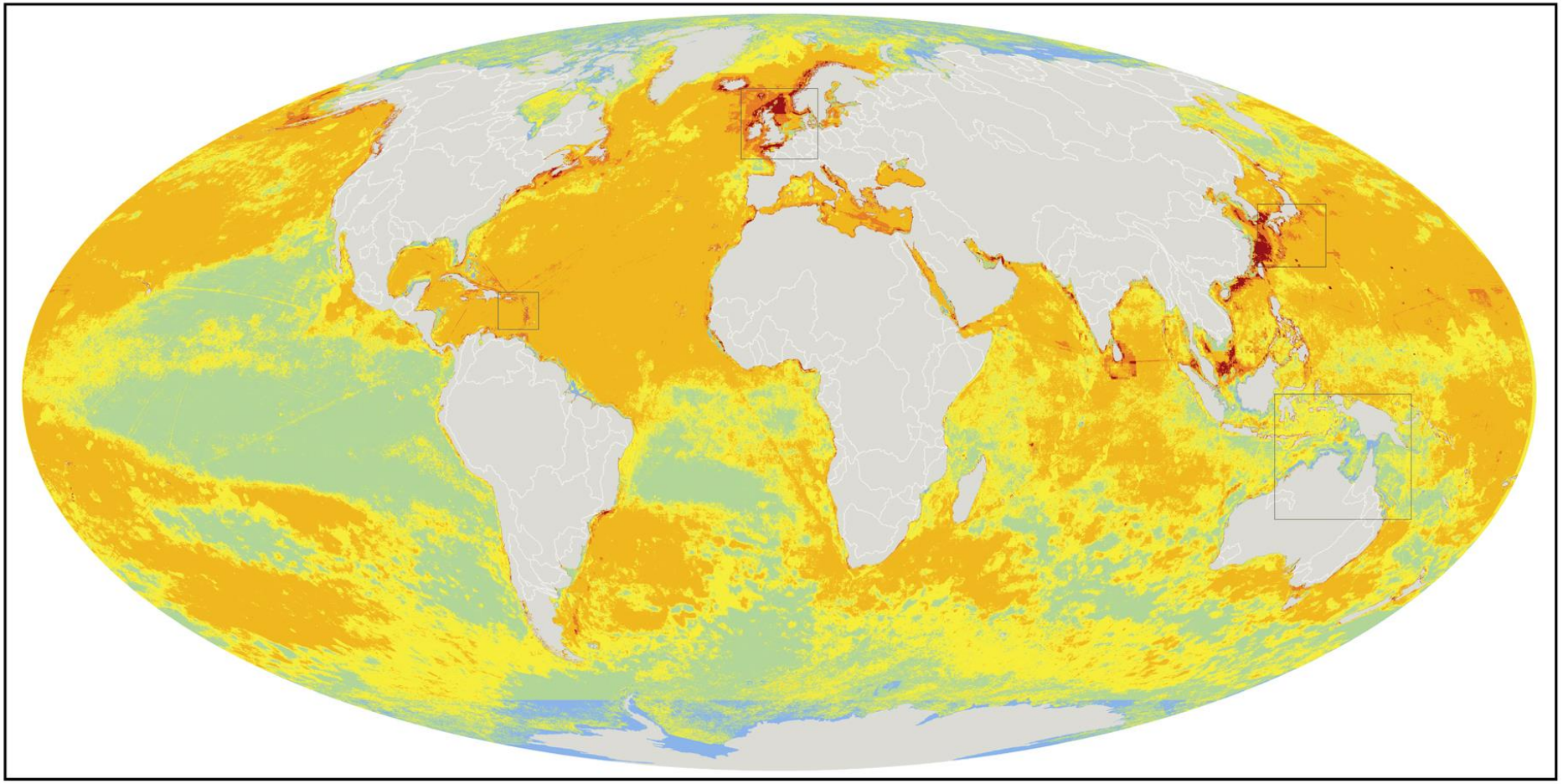


Figure 45:
Interconnections between people, biodiversity, ecosystem health and provision of ecosystem services

Global marine pollution

A Global Map of Human Impacts to Marine Ecosystems

https://www.nceas.ucsb.edu/globalmarine



The most visible and familiar impact of human activity on the marine environment is oil pollution caused by tanker accidents.

Yet despite the scale and visibility of their impacts, **the total quantities of pollutants entering the sea from shipwrecks are dwarfed by those of pollutants introduced from other sources**, like

* domestic sewage,
* industrial discharges,
* urban and industrial run-off,
* spillage,
* explosions,
* sea dumping operations,
* mining,
* agricultural nutrients and pesticides,
* waste heat sources,
* radioactive discharges and natural oil seepages.

Land based sources are estimated to account for around 44% of the pollutants entering the sea and atmospheric inputs account for an estimated 33%. By contrast, shipping and accidental spills account only for around 12%, ocean dumping for 10% and offshore mining for 1%.

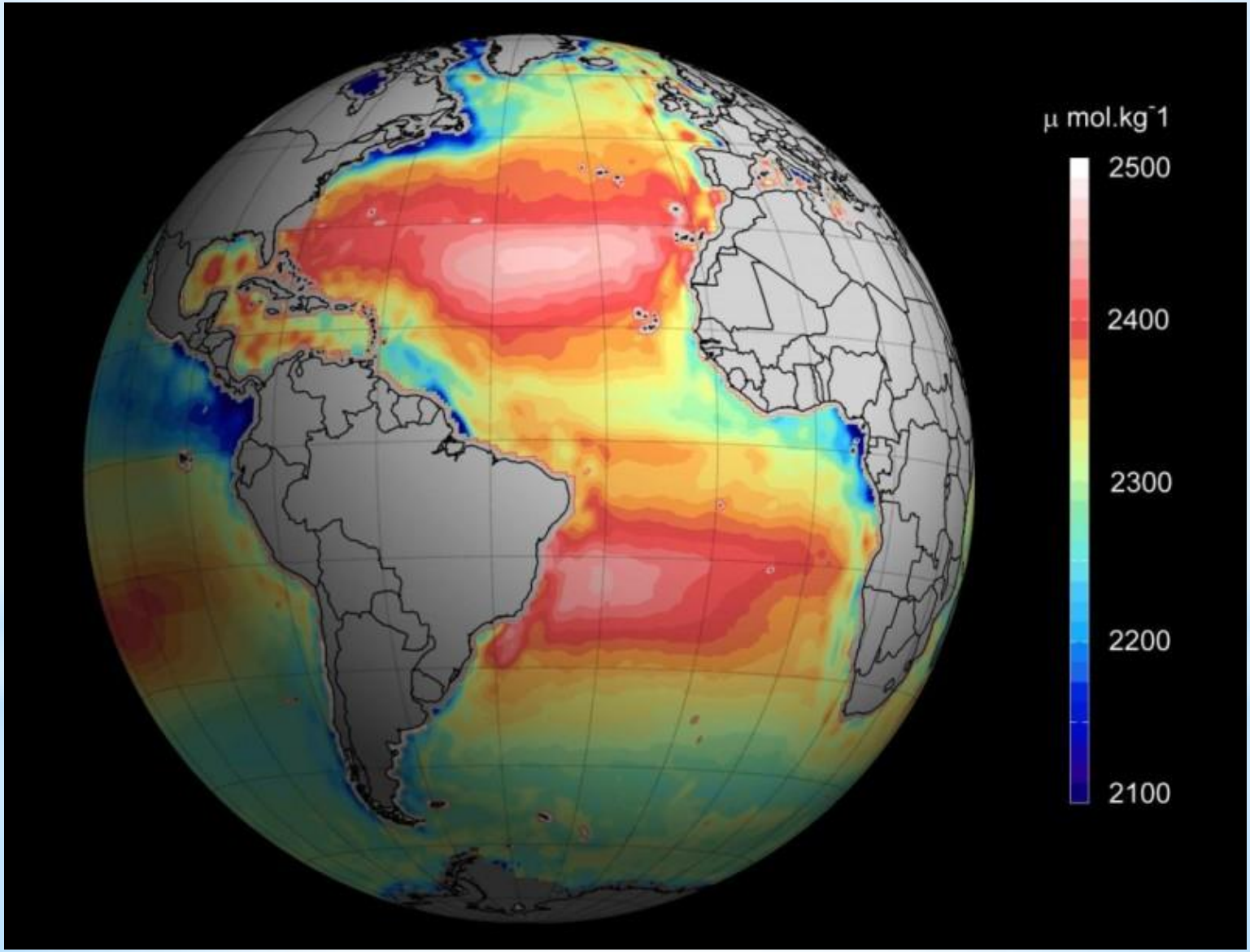
Oil pollution

* Whether by accident or normal ship operation, the marine environment is degraded.
* Accidents resulting in massive spill provide gripping illustrations of the problem of vessel
* pollution.
* While being toxic to marine life, polycyclic aromatic hydrocarbons (PAHs), one of the components in crude oil, are very difficult to clean up, and last for years in the sediment and marine environment.

Large oil spills at sea constitute a threat to the environment, placing enormous demands on the national authorities responsible for response and clean-up operations.

Map of Ocean acidification

http://www.zmescience.com/ecology/pollution-ecology/ocean-acidification-map-18022015/



* Global look at ocean pH reveals that the water is more alkaline (basic) in the open ocean than in many coastal regions. The more alkaline the water is, the better poised it is to resist ocean acidification.
* Ocean acidification is the ongoing decrease in the pH of the Earth's oceans, caused by the uptake of carbon dioxide (CO_2) from the atmosphere. An estimated 30–40% of the carbon dioxide released by humans into the atmosphere dissolves into oceans, rivers and lakes. Unfortunately, that type of pollution is easier to miss, because we live on land – not in the ocean.

Drinking water supply

Drinking water is a basic requirement for life and a determinant of standard of living.

Supply and demand side factors of both surface and ground water determine the level of drinking water available to people.

The supply and demand factors increase with the natural and human factors like pollution. This limits drinking water supply provision and raise the delivery cost.

http://www.cwu.edu/~jacobsend/WaterFaucet.jpg

* According to the estimations of WHO/UNICEF (2014):

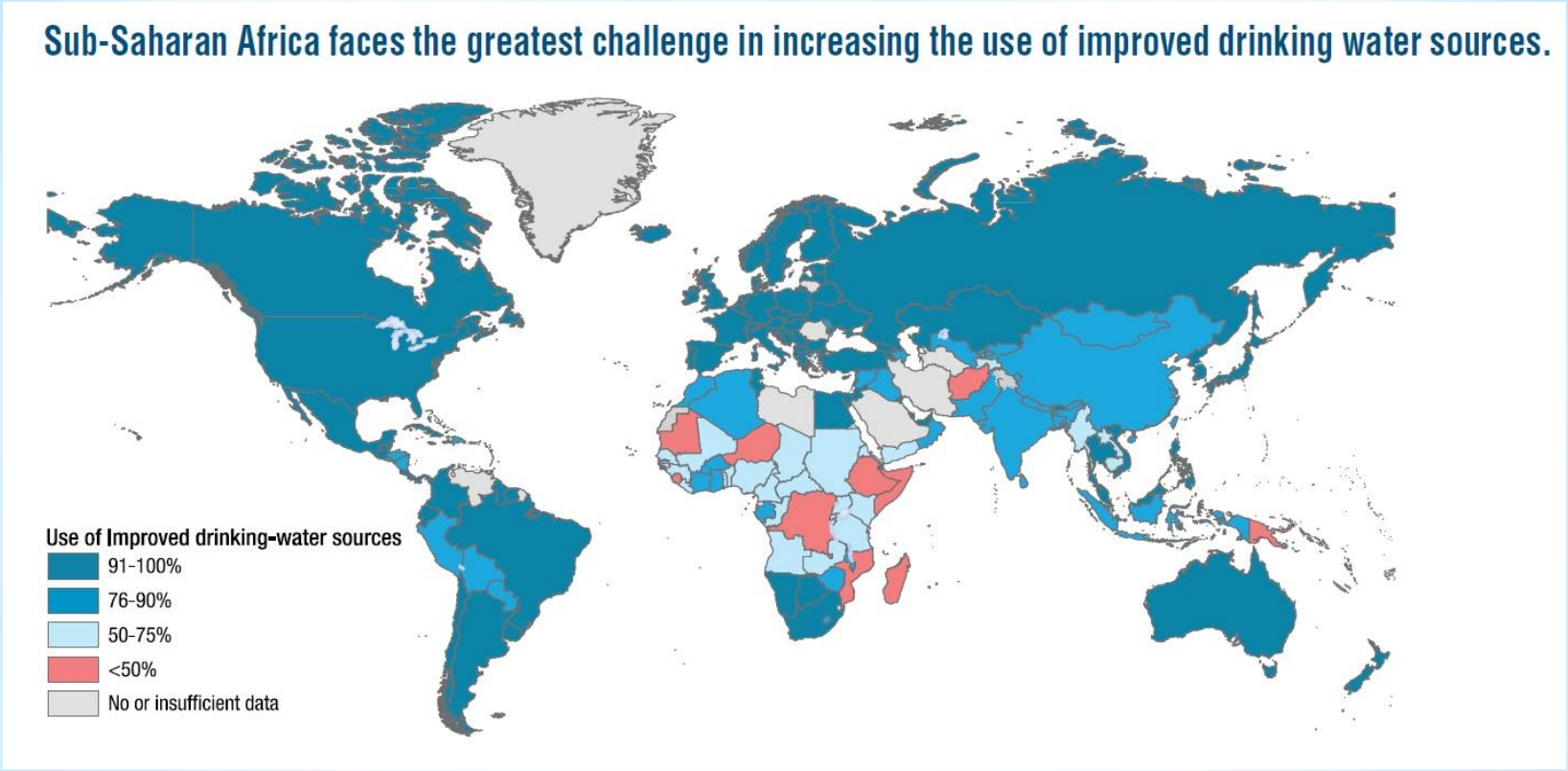
AN ESTIMATED 748 MILLION women, men and children lack access to an improved source of drinking-water.

BILLIONS LACK ACCESS to safe water that is reliably and continuously delivered in sufficient quantities.

SOME 2.5 BILLION PEOPLE —more than one third of the global population— live without basic sanitation facilities.

HUNDREDS OF MILLIONS OF PEOPLE do not have soap and clean water to wash their hands, a simple practice that prevents the spread of diarrhoeal and respiratory illness.

http://static.ibnlive.in.com/



Worldwide use of improved water sources (2008, UNISEF/WHO, 2011)

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