The Abdus Salam
International Centre for Theoretical Physics

United Nations
Educational, Scientific and
Cultural Organization

IAEA
International Atomic Energy Agency

2018-8

Winter College on Optics in Environmental Science

2 - 18 February 2009

Introductory lecture on the environment, its composition, and phenomena involving optical radiation

Singh R.P.
George Mason University
U.S.A.

Environment, Its Composition and Phenomena Involving Optical Radiation

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Orange, CA, USA
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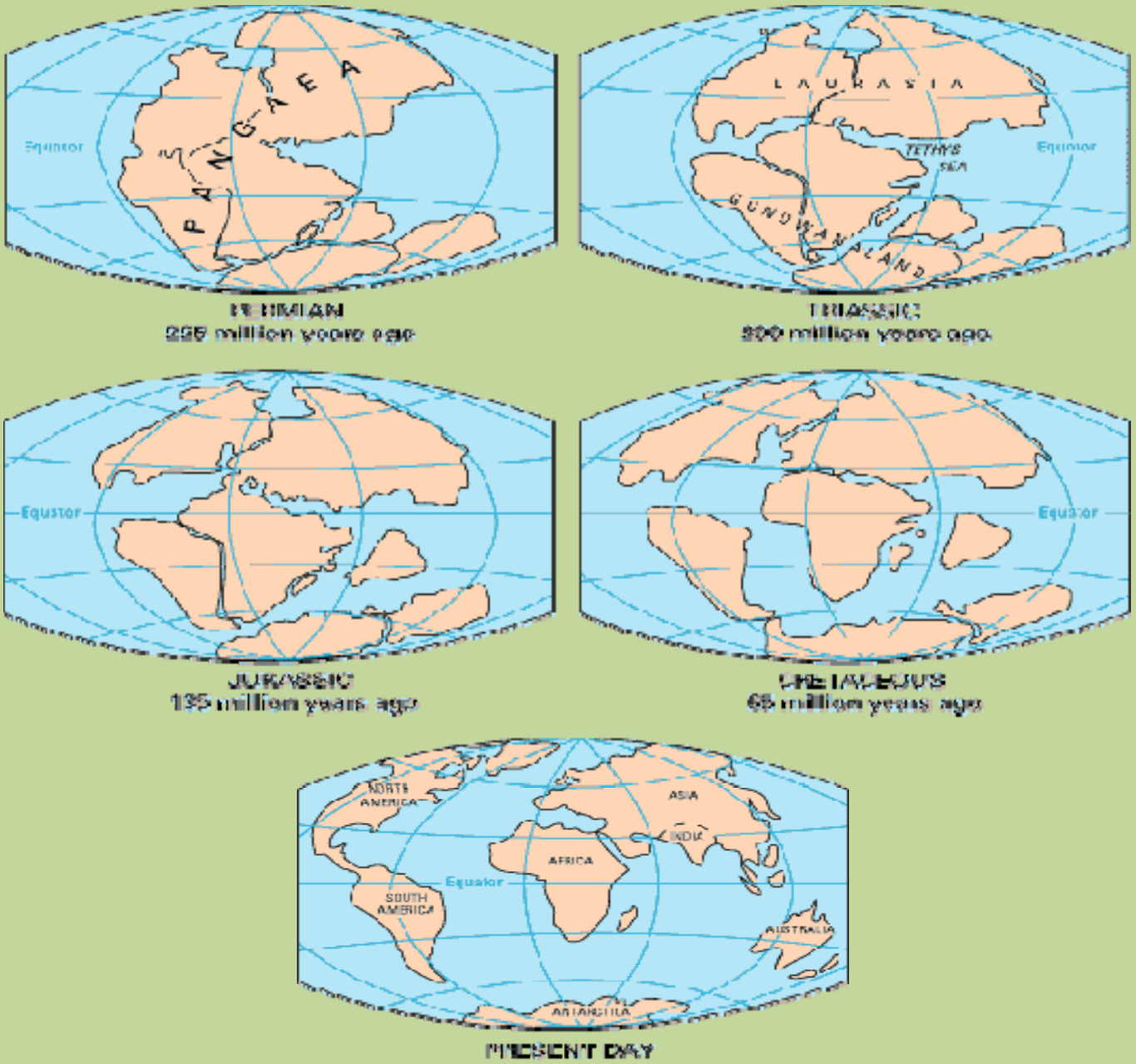
Outline

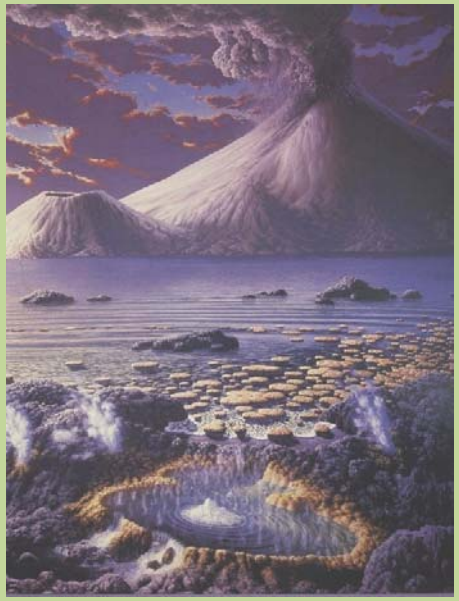
- - Earth and Earth Processes
- - Earth Structure
- - Population and Environment
- - Why Environment?
- - Sun and Earth Interaction

- Formation of Earth 4.5 billion years ago
  - Accretion of cosmic gas and dust condensed from solar nebula
  - Gravitational collapse
  - Composition today lacks nobel gases e.g. He, Ne, Ar [cf. cosmic abundances]
- Loss of primordial atmosphere
  - Gases and volatile compounds blown away by impacts or strong solar wind before gravitational field strong enough
  - Subsequent input from extraterrestrial sources e.g. meteorites and Comets
- 92 natural elements.
  - Assemblage of atoms roughly conserved since.


PANGAEA
Equator
LAURASIA
TETHYS SEA
GONDWANALAND
Equator
Equator
Equator
NORTH AMERICA
ASIA
INDIA
AFRICA
Equator
SOUTH AMERICA
AUSTRALIA
ANTARCTICA

Today

Early Archean



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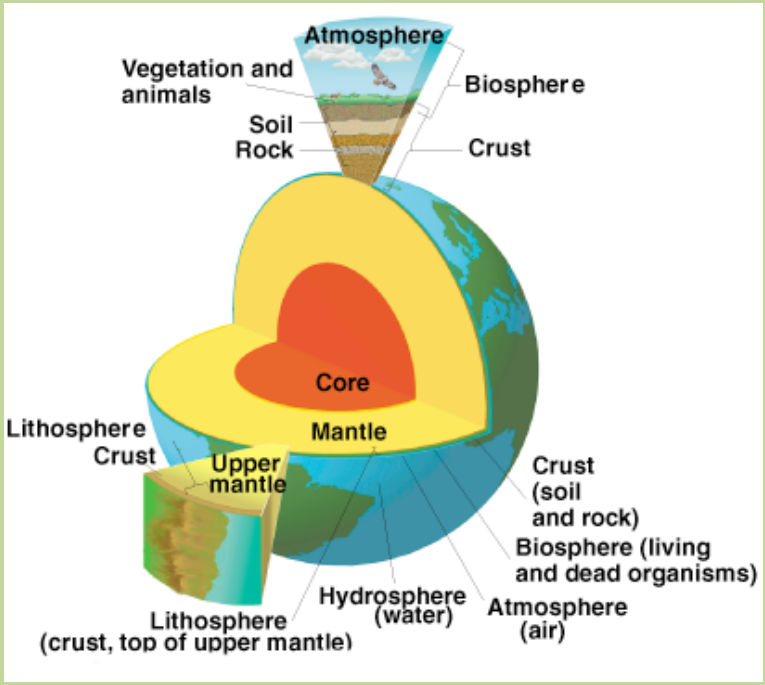
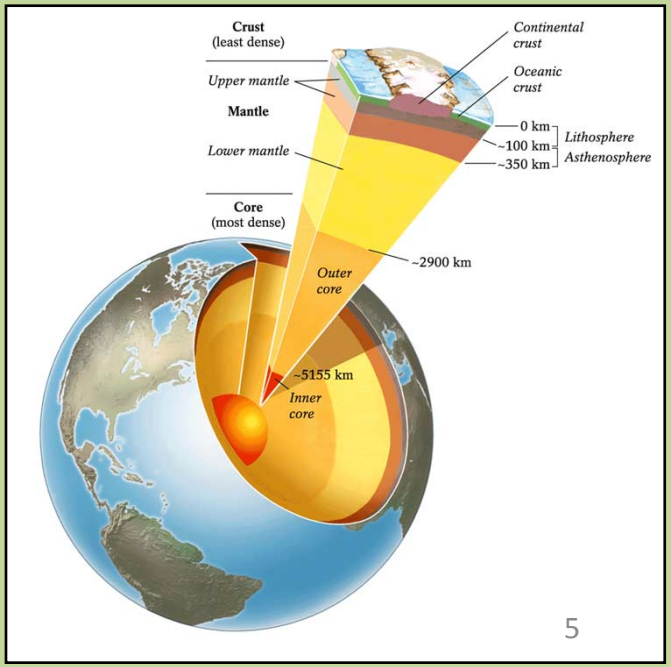
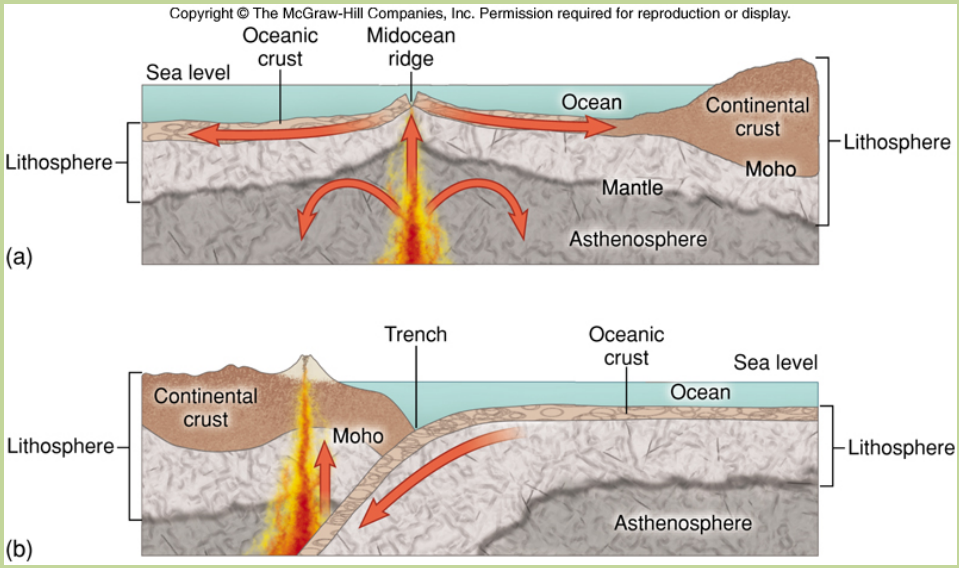
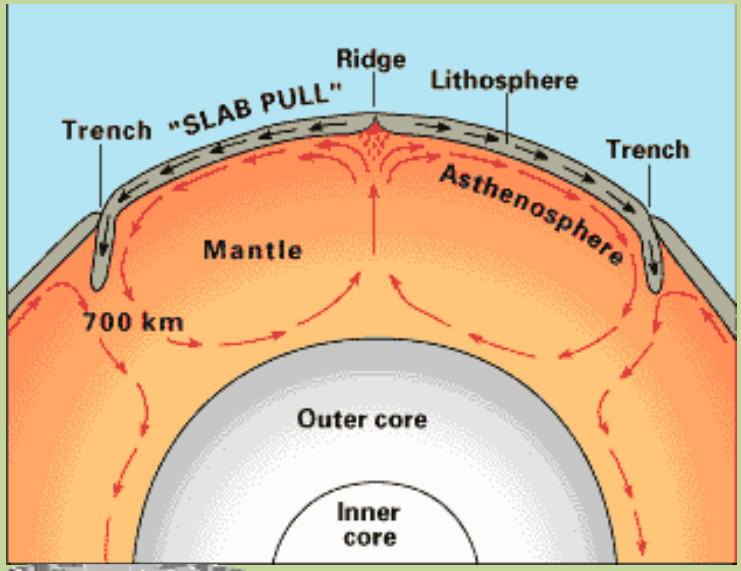




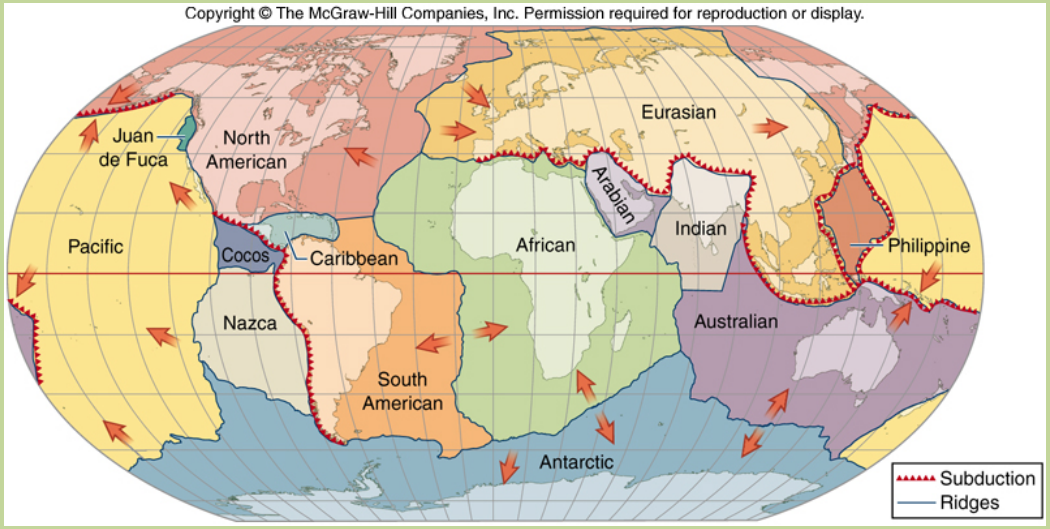




•Lithosphere – Land and Land cover (30%)

•Hydrosphere – Ocean (70%)

Atmosphere which is linkage between Lithosphere and Hydrosphere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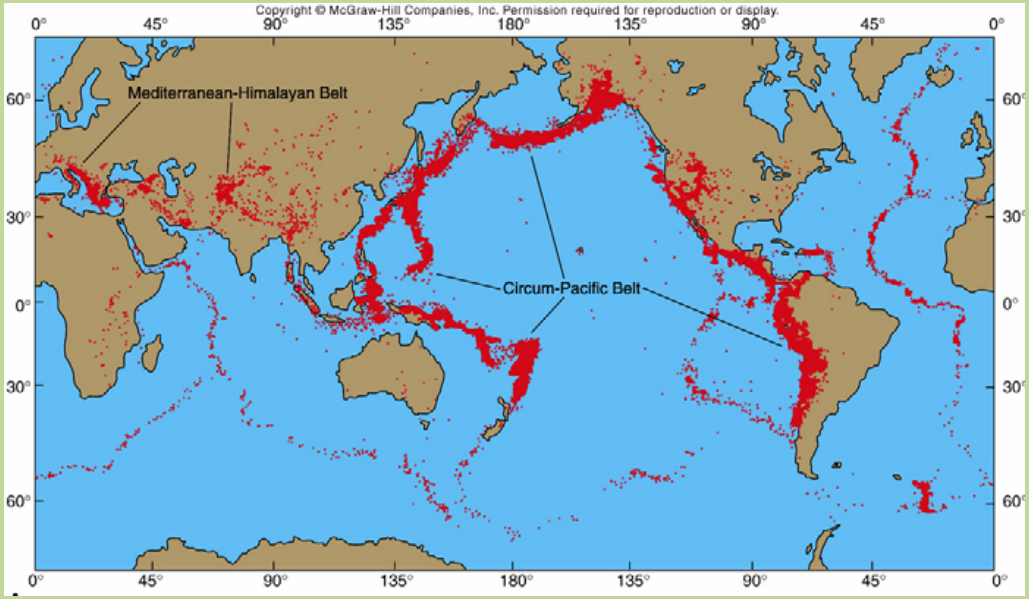
Juan de Fuca
North American
Eurasian
Arabian
Indian
Philippine
Pacific
Cocos
Caribbean
African
Nazca
Australian
South American
Antarctic
Subduction
Ridges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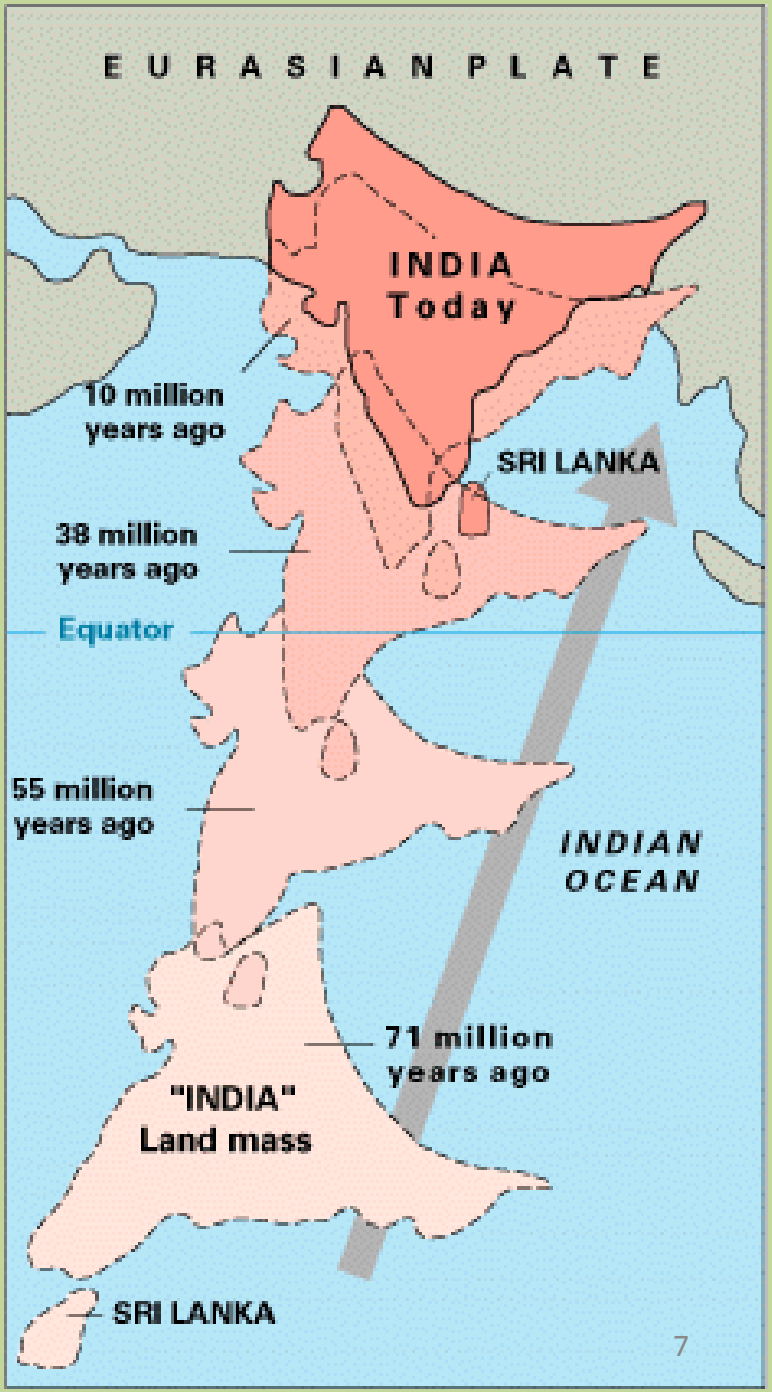
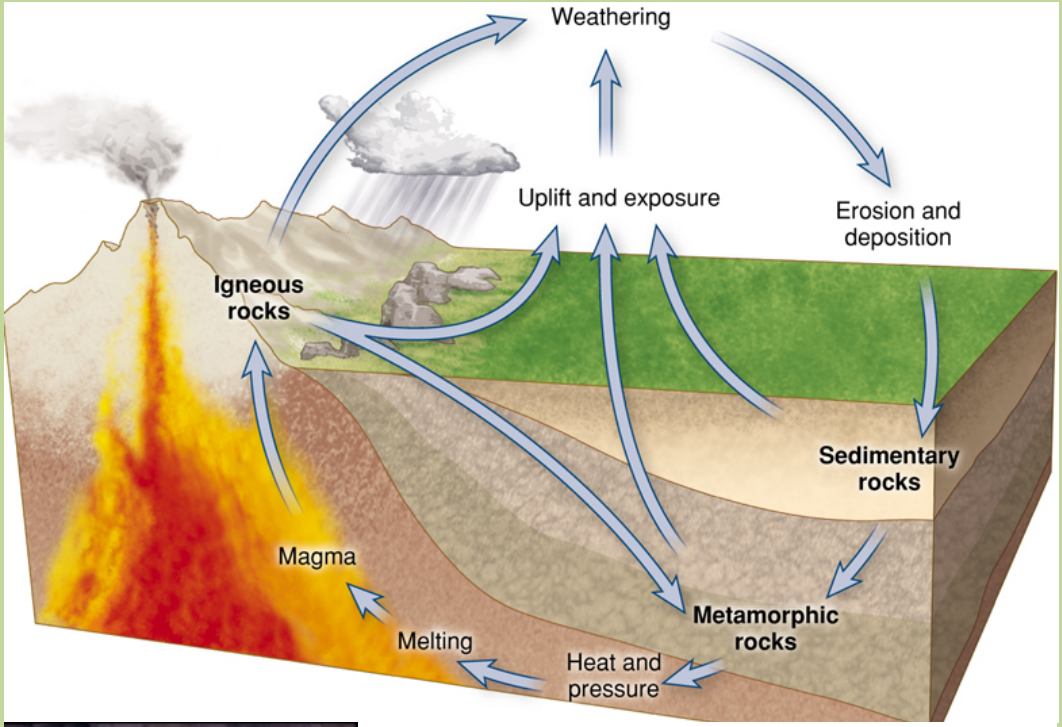
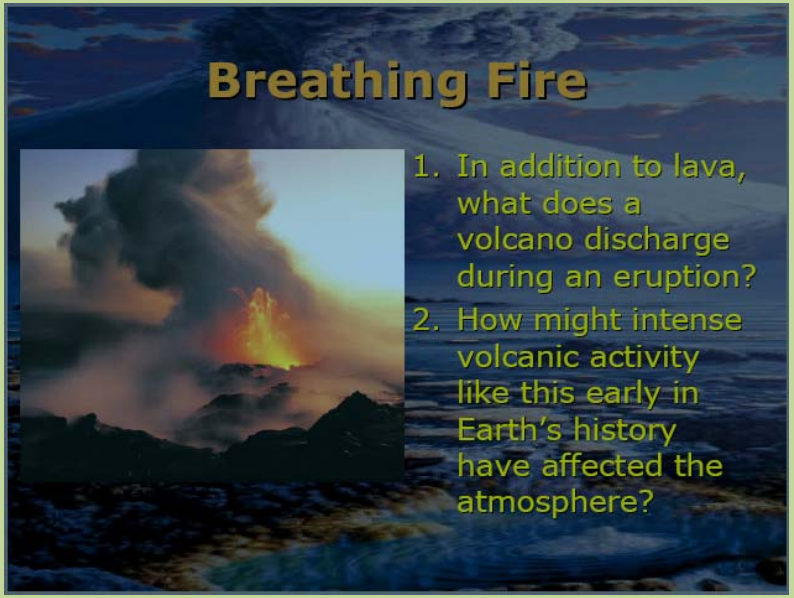
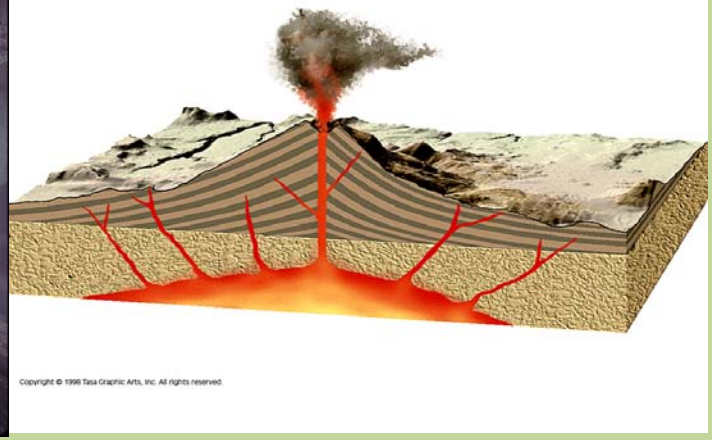
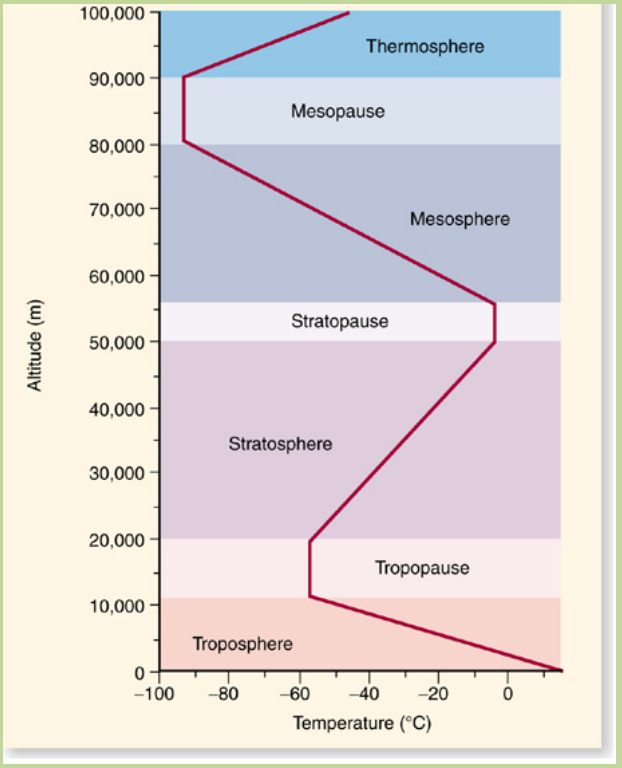
Mediterranean-Himalayan Belt
Circum-Pacific Belt

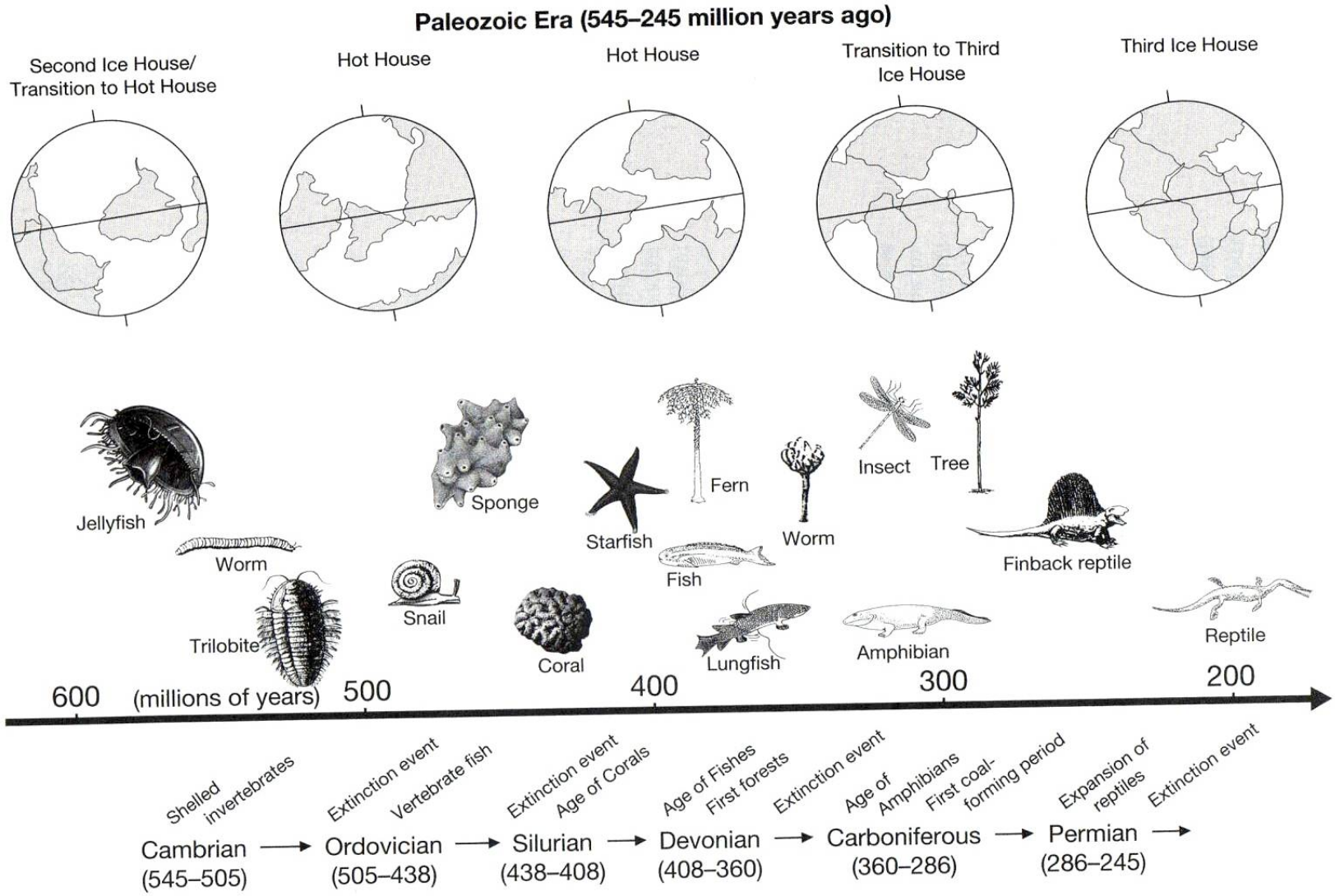

EURASIAN PLATE
INDIA
Today
10 million
years ago
SRI LANKA
38 million
years ago
Equator
55 million
years ago
INDIAN
OCEAN
71 million
years ago
"INDIA"
Land mass
SRI LANKA


Weathering
Uplift and exposure
Erosion and deposition
Igneous rocks
Sedimentary rocks
Magma
Metamorphic rocks
Melting
Heat and pressure


Breathing Fire
1. In addition to lava, what does a volcano discharge during an eruption?
2. How might intense volcanic activity like this early in Earth's history have affected the atmosphere?




Thermosphere
Mesopause
Mesosphere
Stratopause
Stratosphere
Tropopause
Troposphere
Altitude (m)
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
−100
−80
−60
−40
−20
0
Temperature (°C)



Evolution of Life on the Earth

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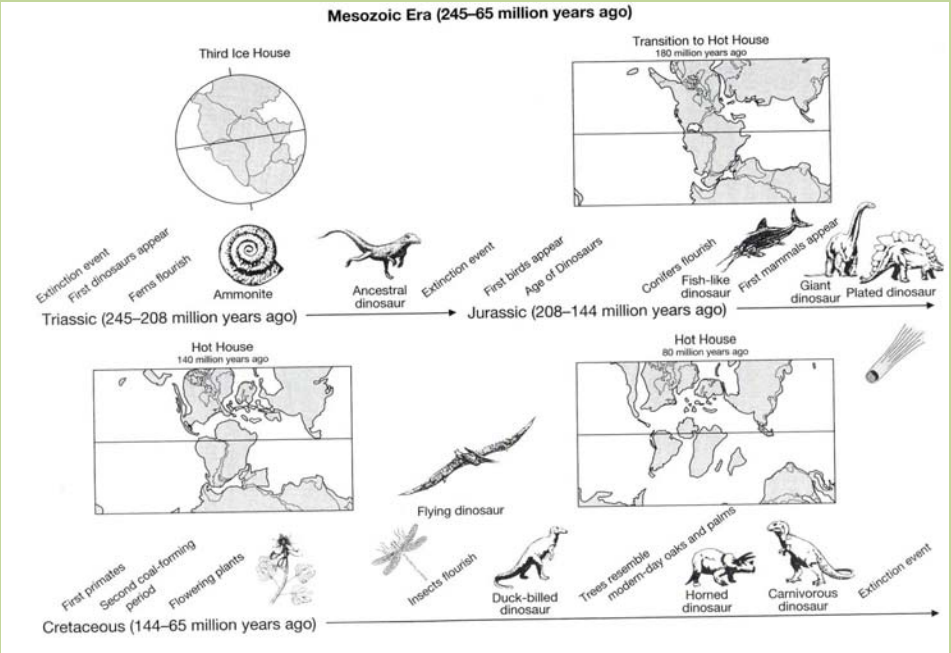
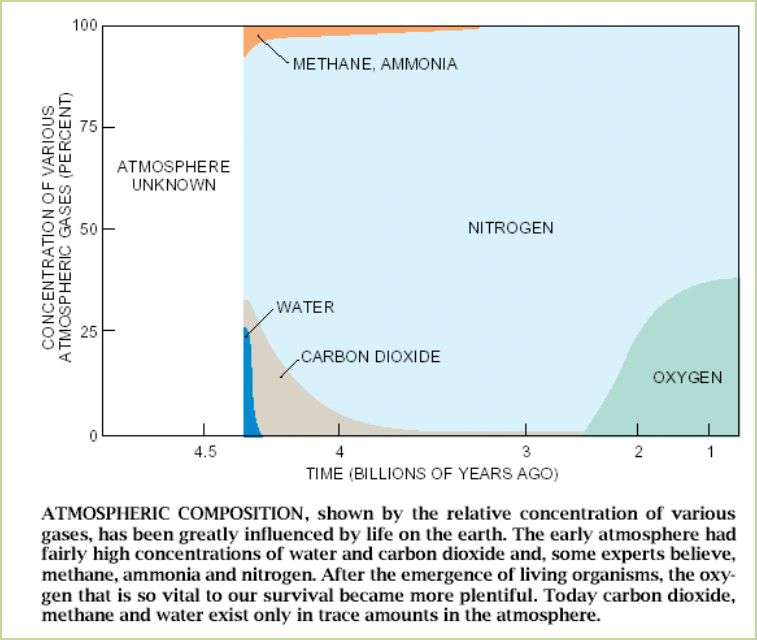
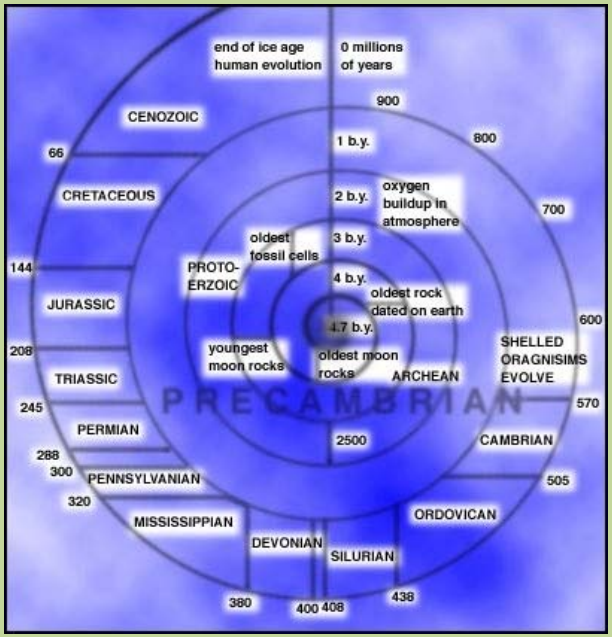
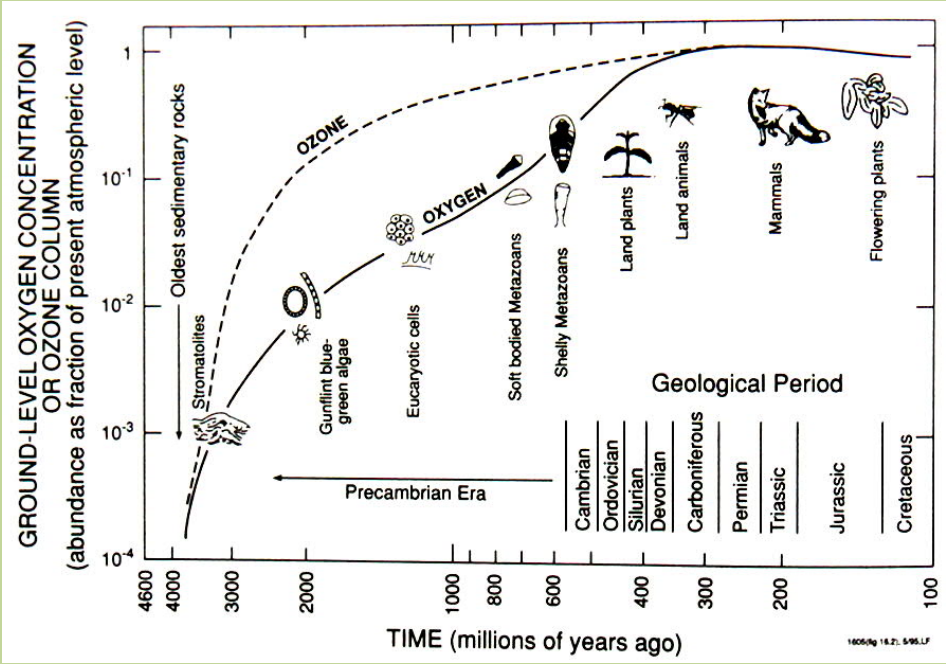




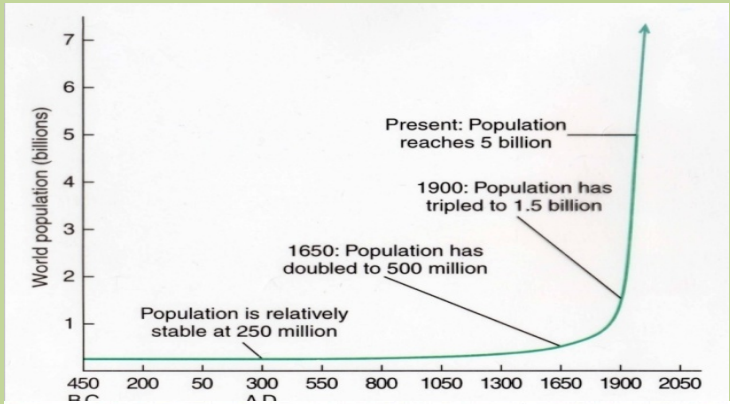
ATMOSPHERIC COMPOSITION, shown by the relative concentration of various gases, has been greatly influenced by life on the earth. The early atmosphere had fairly high concentrations of water and carbon dioxide and, some experts believe, methane, ammonia and nitrogen. After the emergence of living organisms, the oxygen that is so vital to our survival became more plentiful. Today carbon dioxide, methane and water exist only in trace amounts in the atmosphere.

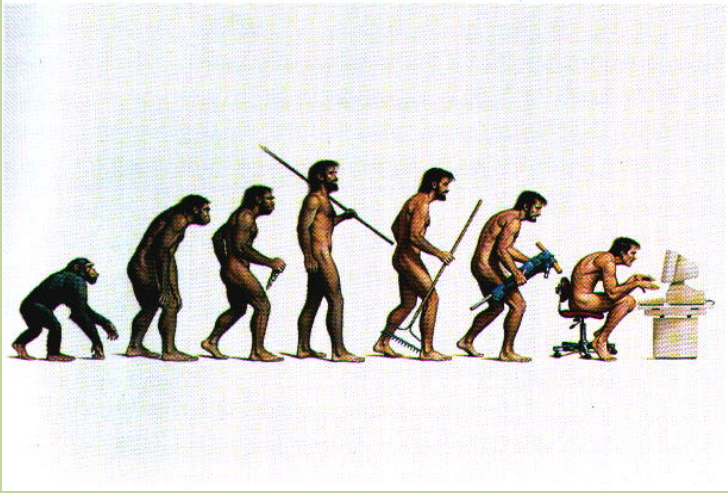
Evolution of Life on the Earth

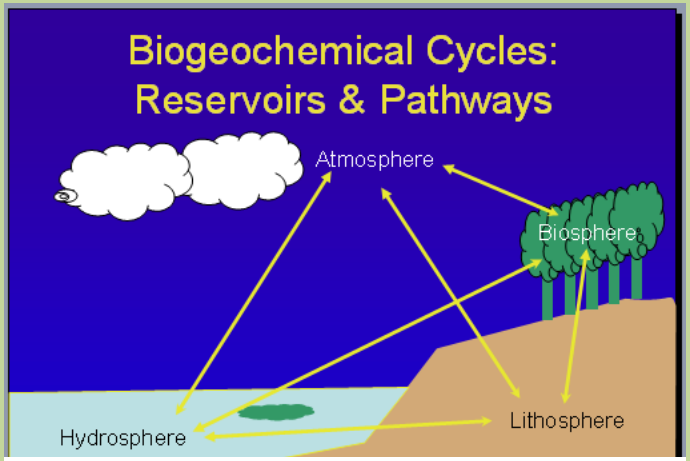


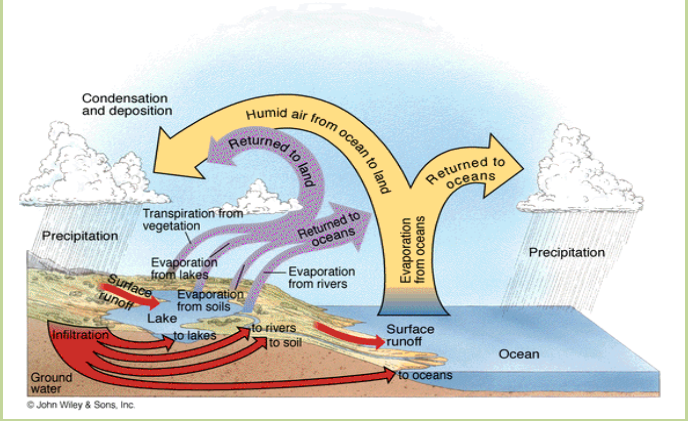


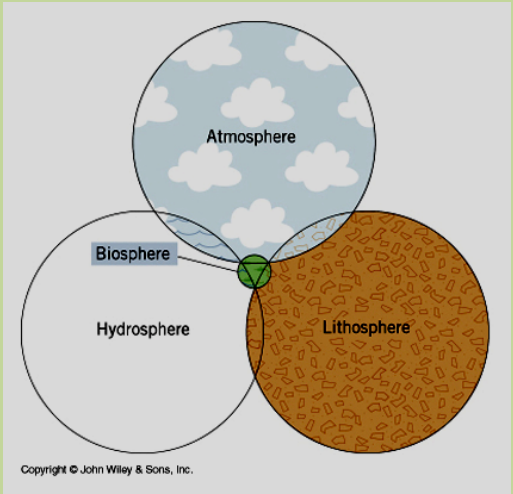
By 2030 the world's population - > 8 billion











Coupling – Lithosphere – Hydrosphere – Atmosphere

This coupling has become complex with the Human interactions

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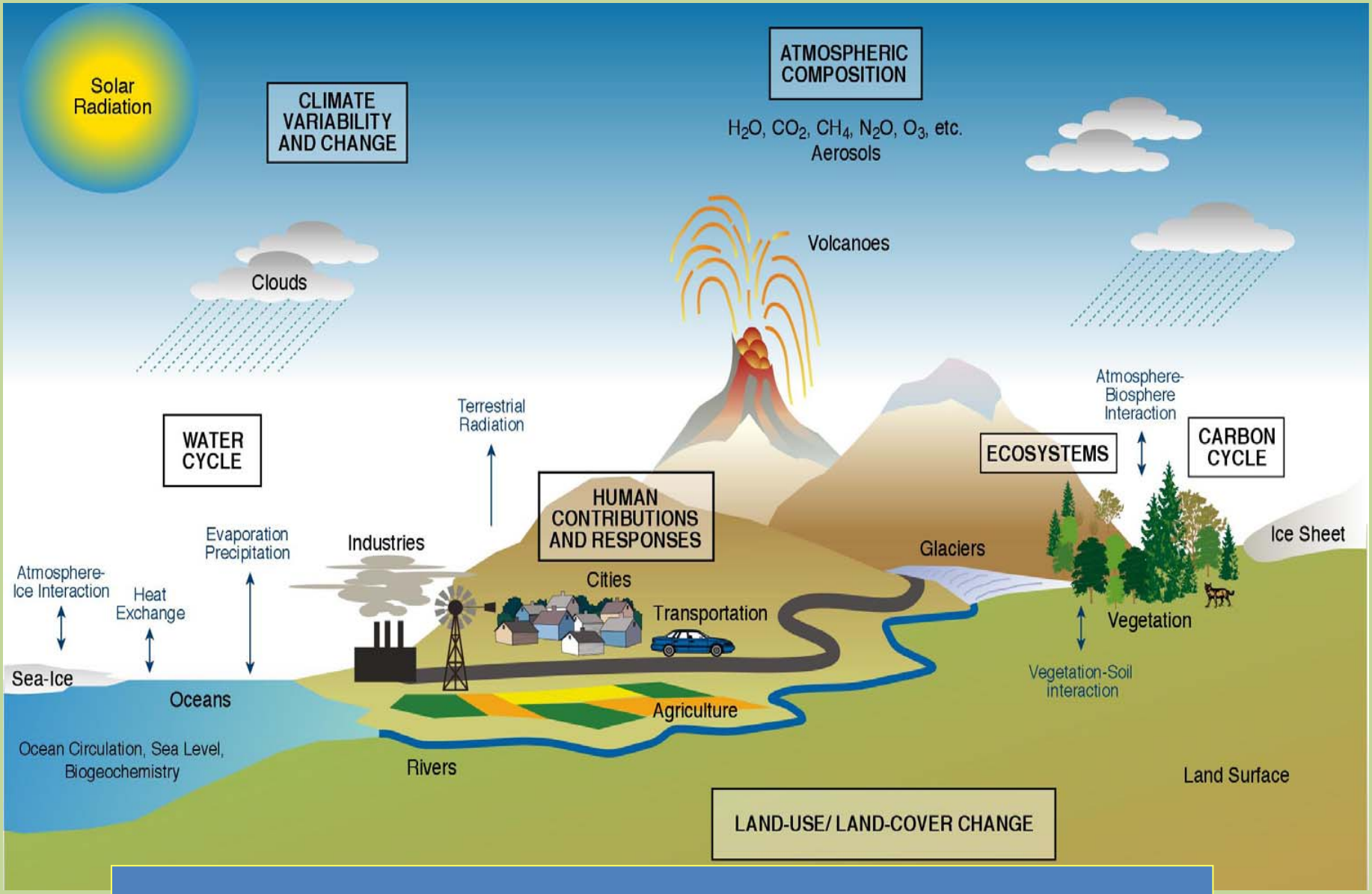
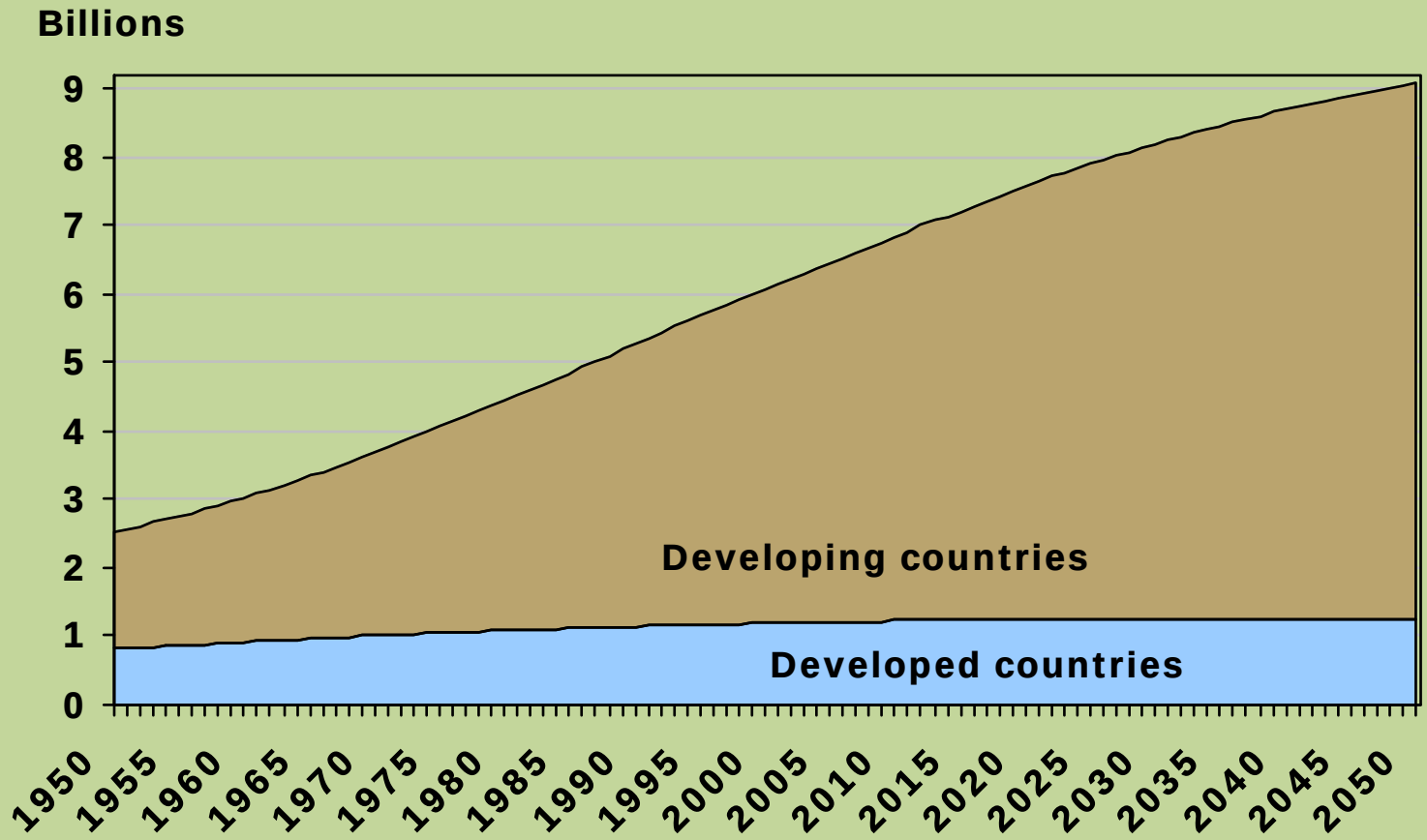


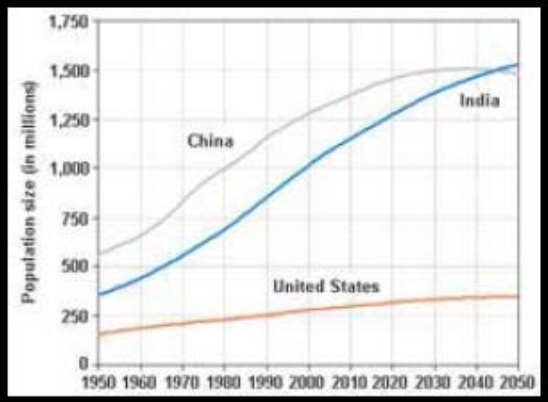
The dynamic Earth is a complex system of systems.

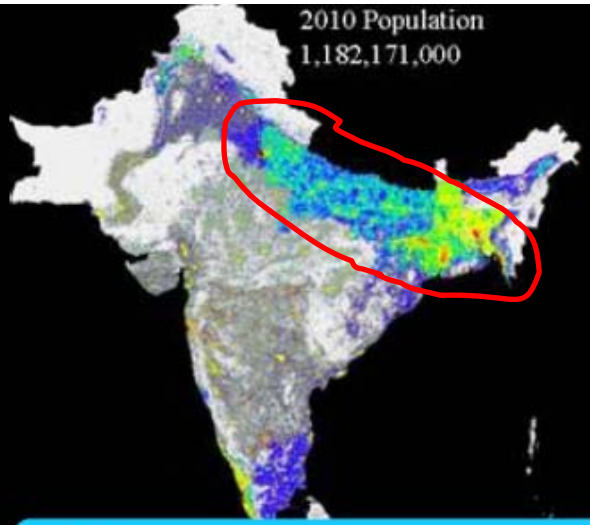
Global population growth: A developing country phenomenon

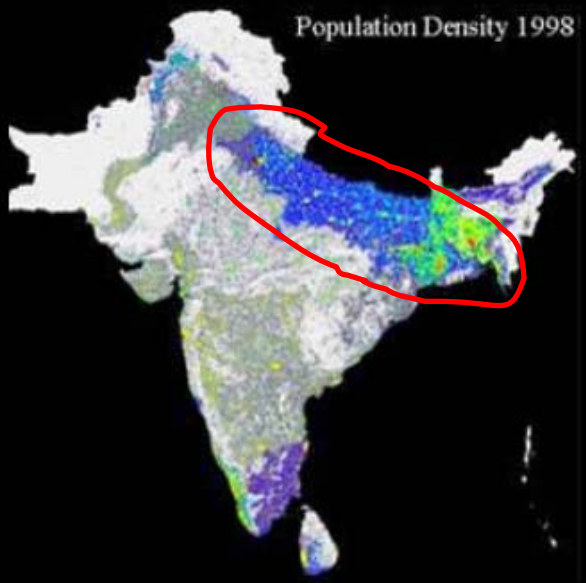


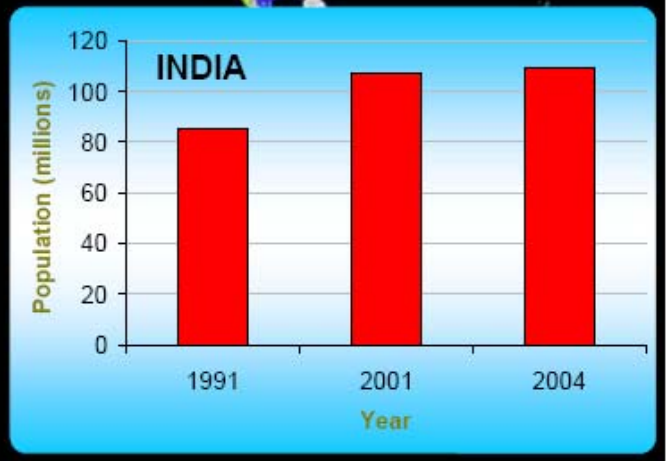
Source: United Nations Populations Division, *World Population Prospects, The 2004 Revision*, medium variant.

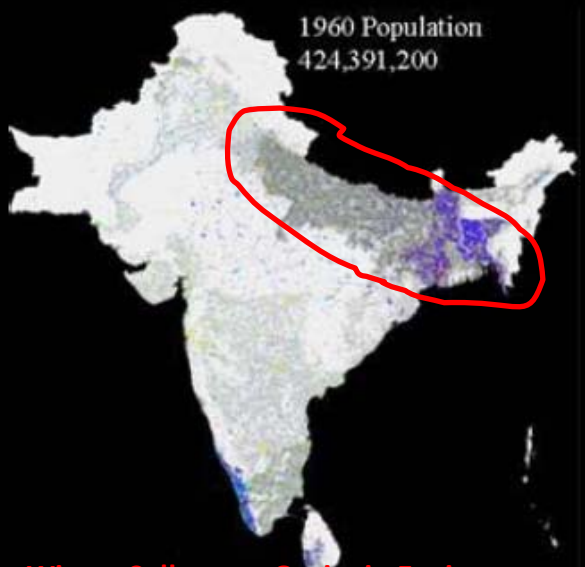
Projected Population Trend

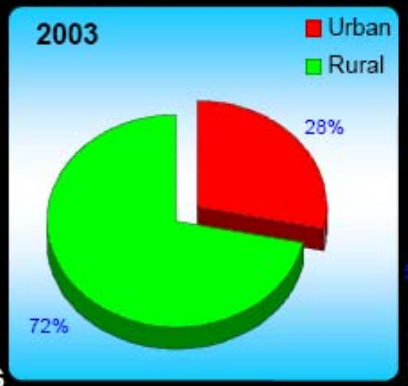


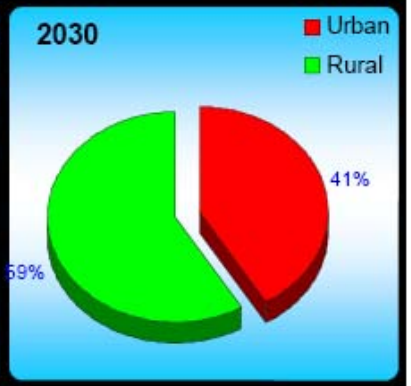






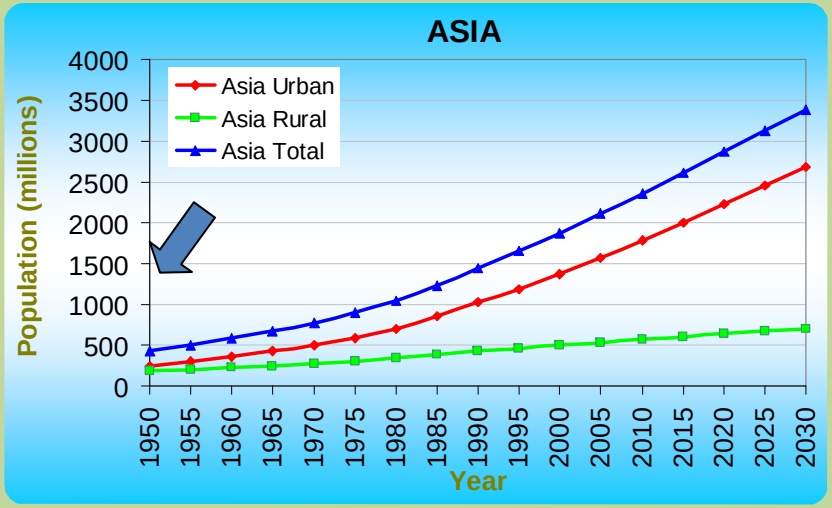


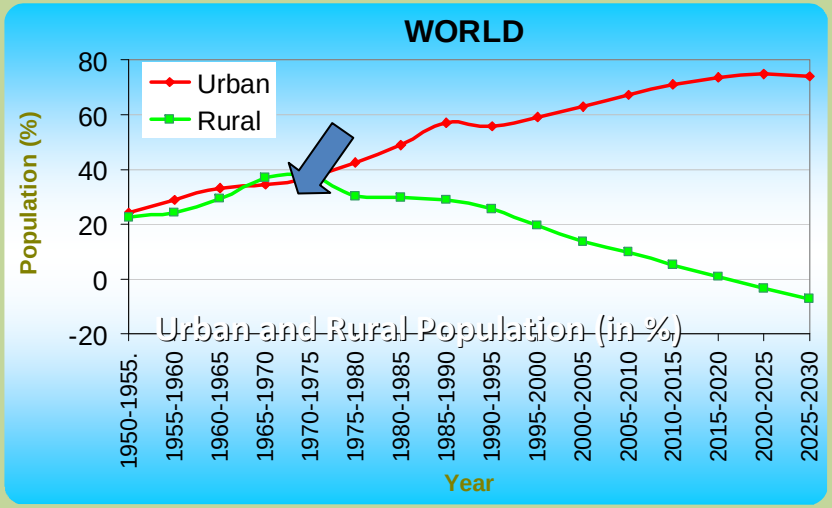




Source: United Nations Population Division 1998

Population growth trend (World and Asia)
(Urban vs Rural)

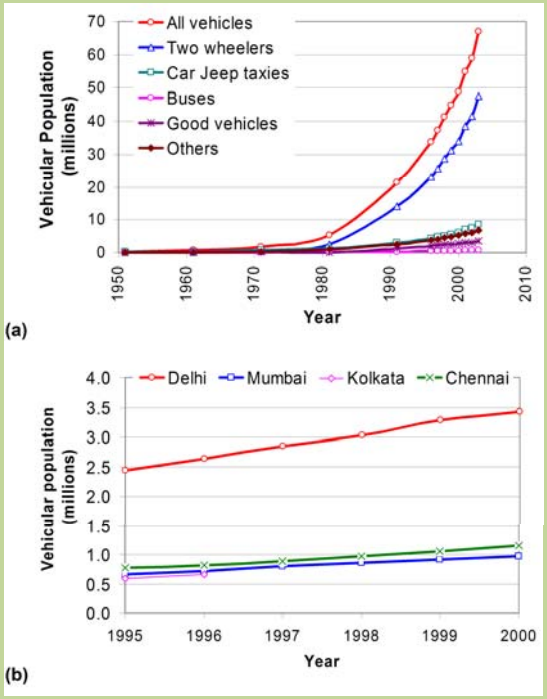


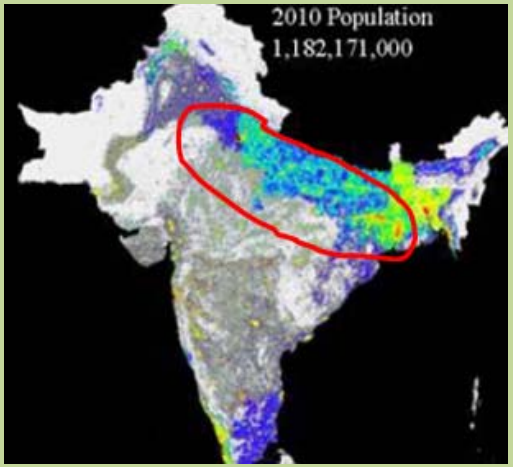


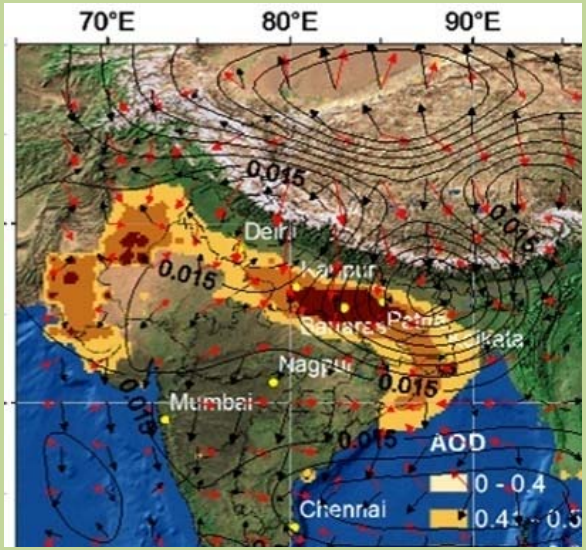
Urban and Rural Population (in %)

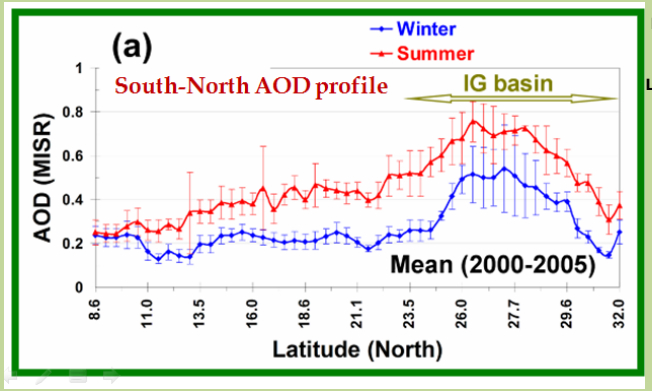
Demography

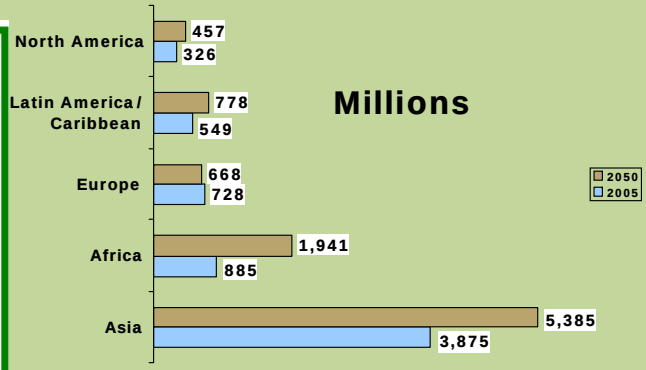
Demographic and Health Indicators	India	Asia (excl. Middle East)	World
Total Population (in thousands of people)			
1950	357,561	1,331,635	2,519,495
2002	1,041,144	3,493,424	6,211,082
2025 (projected)	1,351,801	4,345,549	7,936,741
Population Density (people per square km), 2000:	306.9	136.5	45.1
Average Annual Population Growth Rate, 1980-2000			
Total	1.9%	1.6%	1.6%
In rural areas	1.6%	0.9%	0.9%
In urban areas	3.0%	3.1%	2.4%



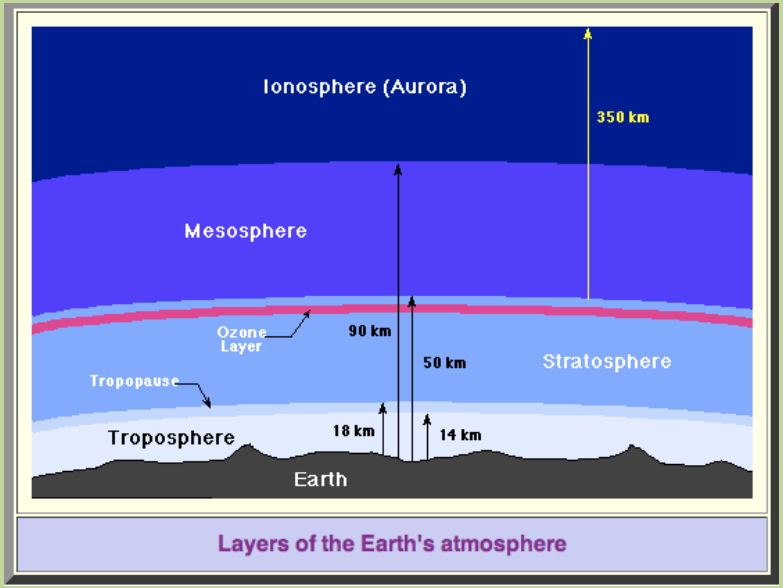




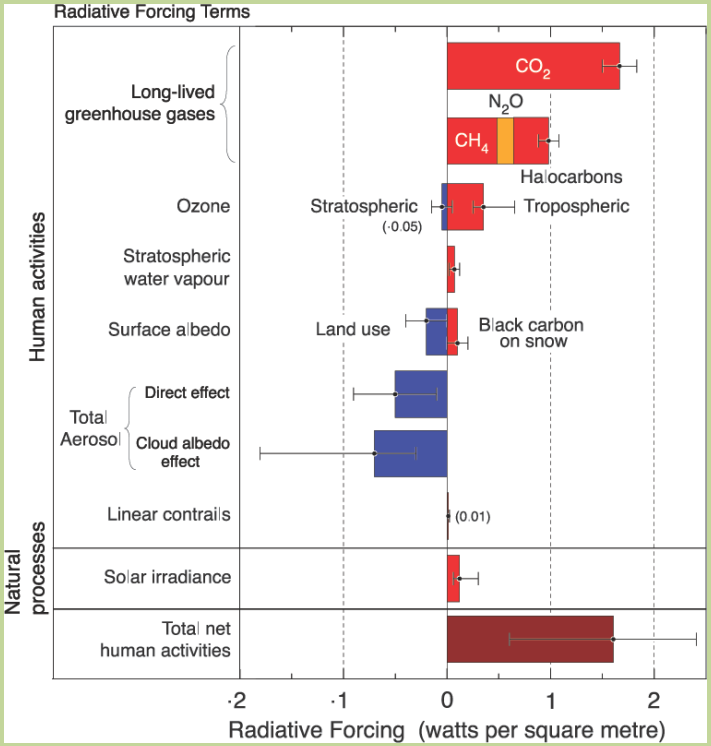


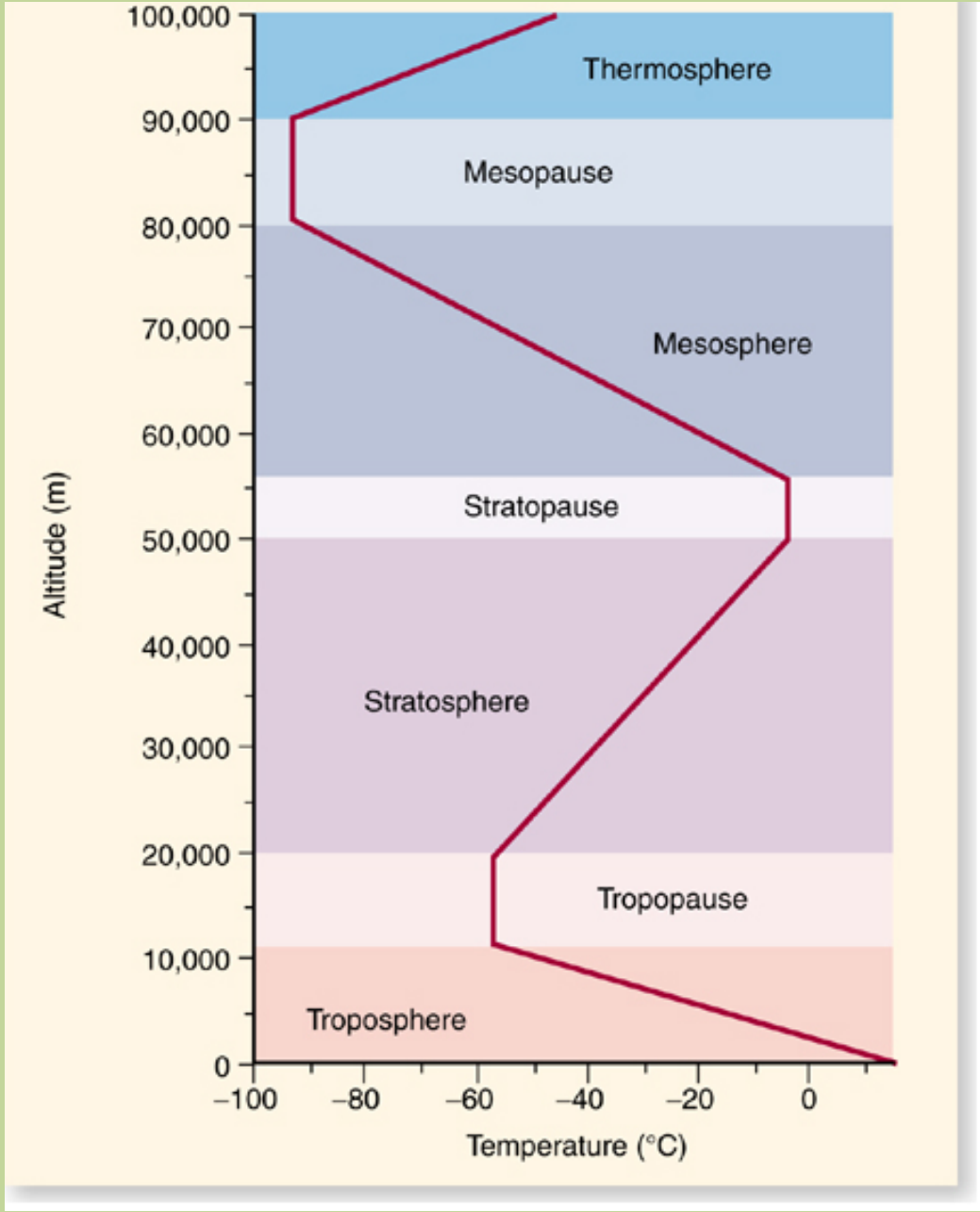


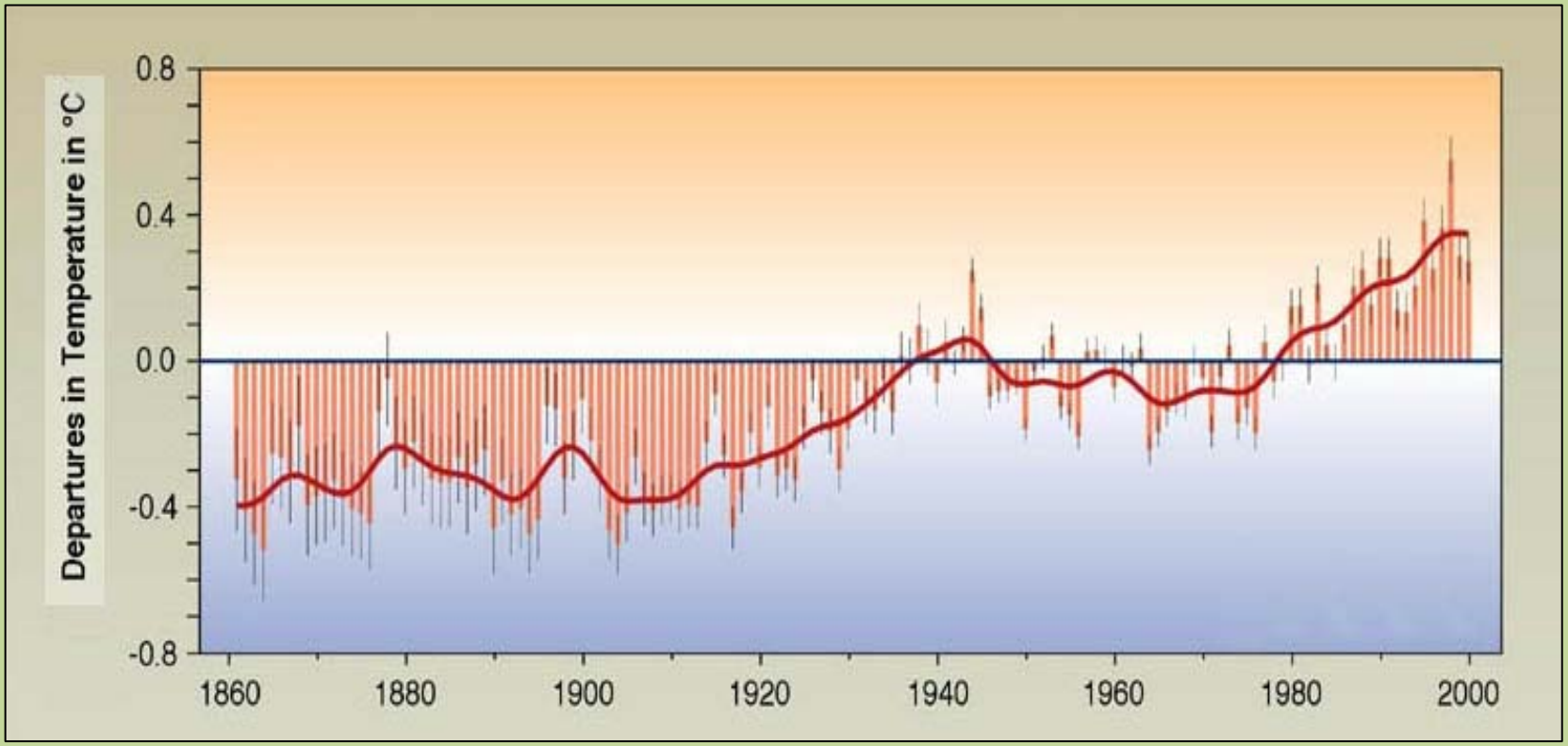
Europe is the only world region projected to decline in population by 2050

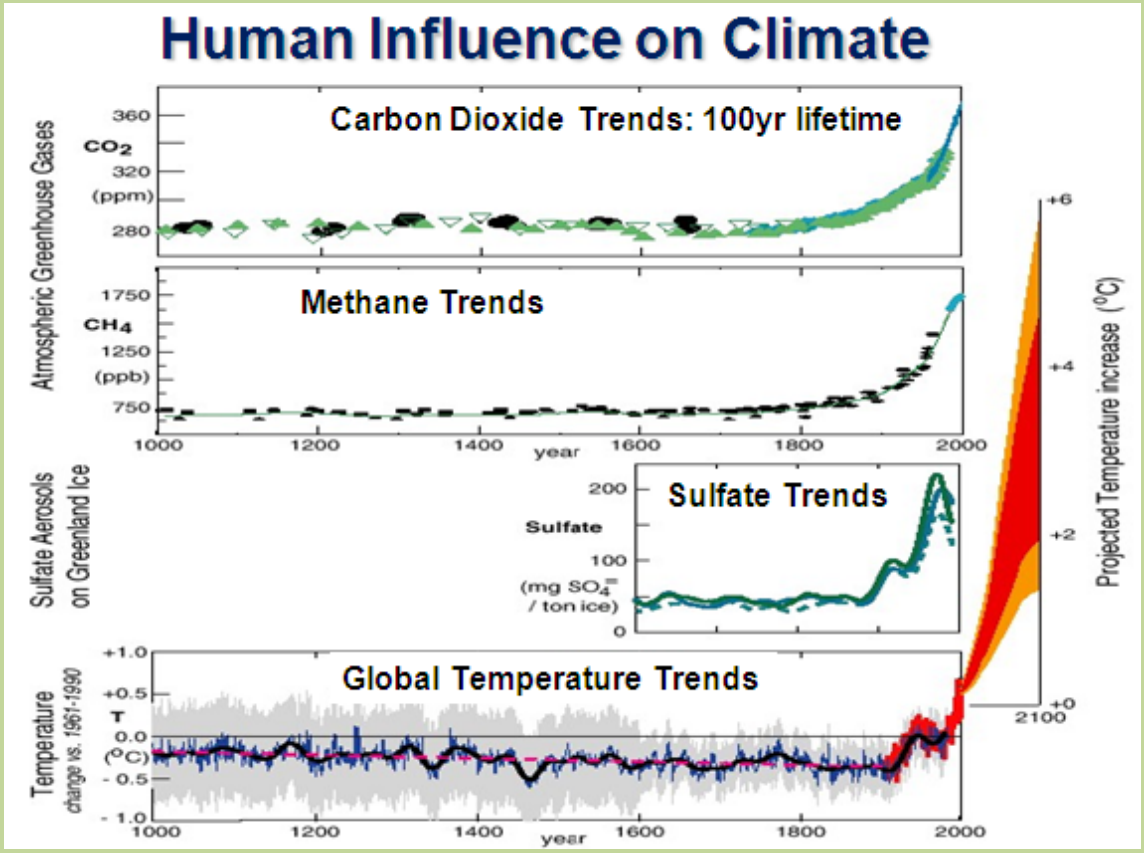


Layers of the Earth's atmosphere

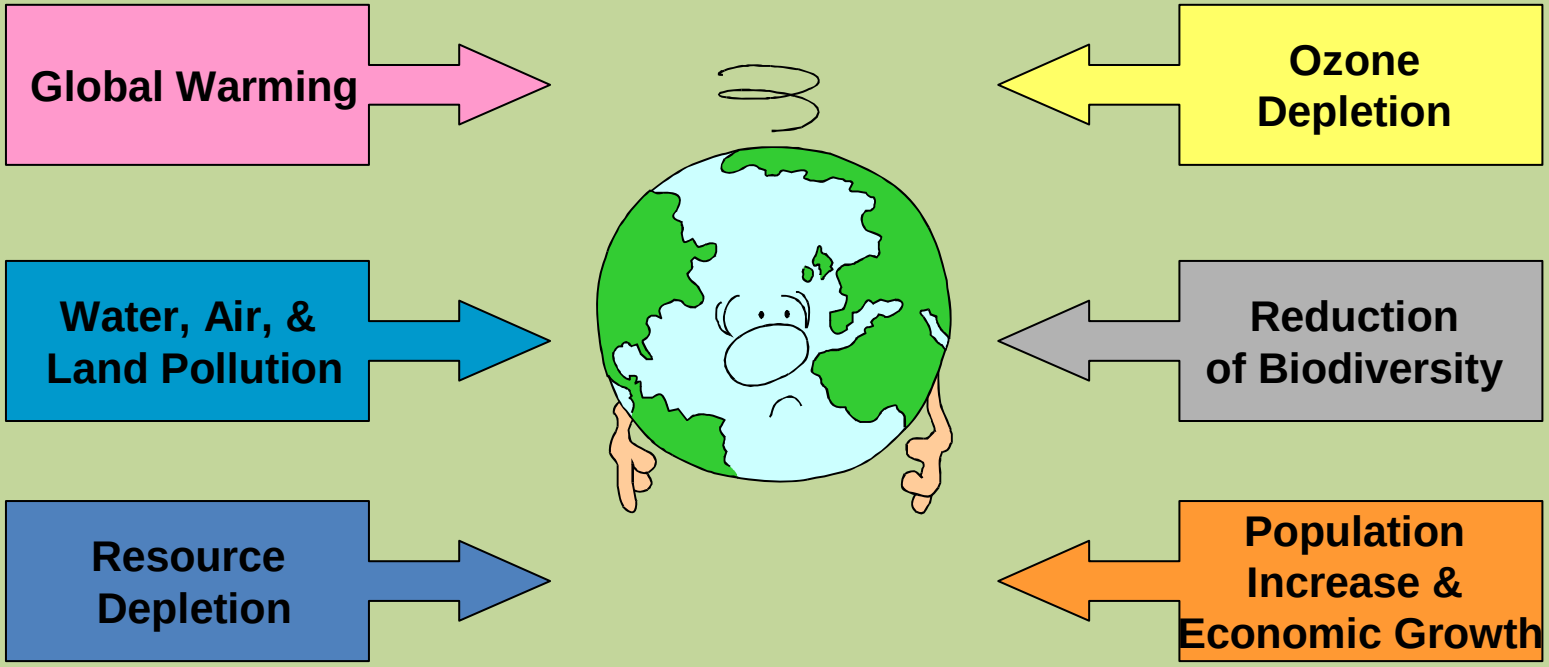





Departures in Temperature in °C
0.8
0.4
0.0
-0.4
-0.8
1860
1880
1900
1920
1940
1960
1980
2000


Human Influence on Climate
Carbon Dioxide Trends: 100yr lifetime
Atmospheric Greenhouse Gases
360
CO2
320
(ppm)
280
Methane Trends
1750
CH4
1250
(ppb)
750
1000
1200
1400
year
1600
1800
2000
Sulfate Trends
Sulfate Aerosols on Greenland Ice
200
Sulfate
100
(mg SO4 / ton ice)
0
Global Temperature Trends
Temperature change vs. 1961-1990
+1.0
+0.5
T
0.0
(°C)
- 0.5
- 1.0
1000
1200
1400
year
1600
1800
2000
+6
+4
+2
+0
2100
Projected Temperature increase (°C)

Human activity = impacts



Hazards

Atmosphere

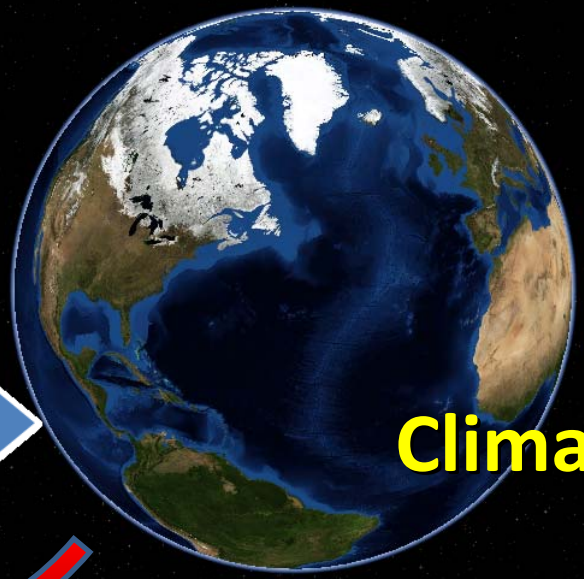
- Hurricanes
- Dust storms
- Thunderstorms
- Tornadoes
- Wind
- Fog
- Extreme precipitation

Land

- Landslides
- Extreme temperatures
- Floods and Flash floods
- Volcanoes
- Earthquakes
- Snow Avalanche
- Epidemics
- Wildland fire

Ocean

- Tsunamis
- Chlorophyll bloom (HABs)
- El nino and la nina
- Snow and ice
- Oil Spill

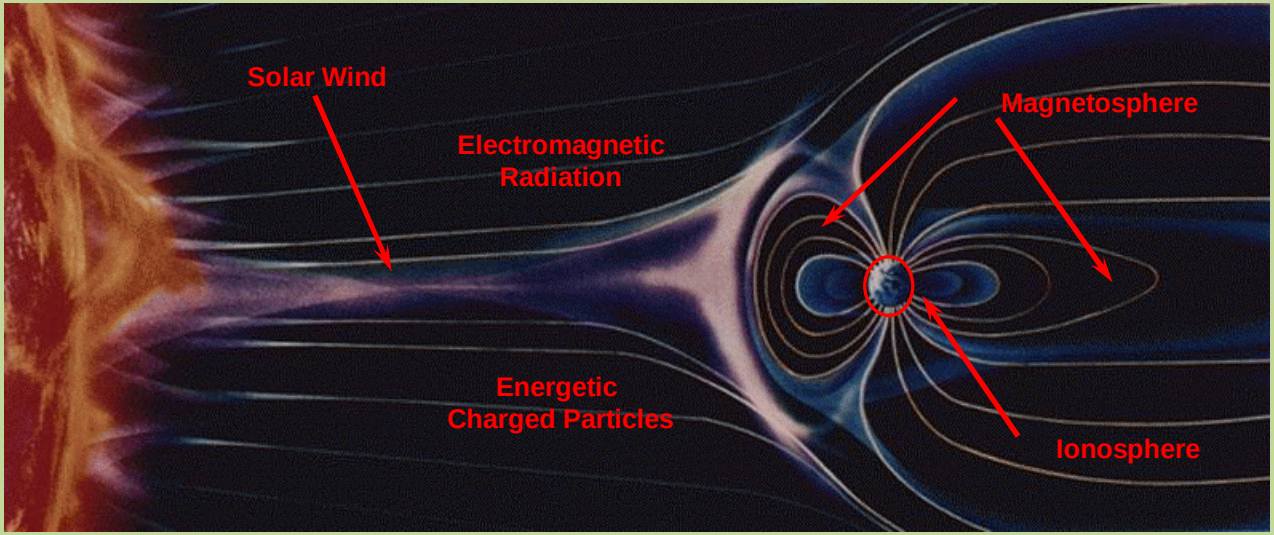


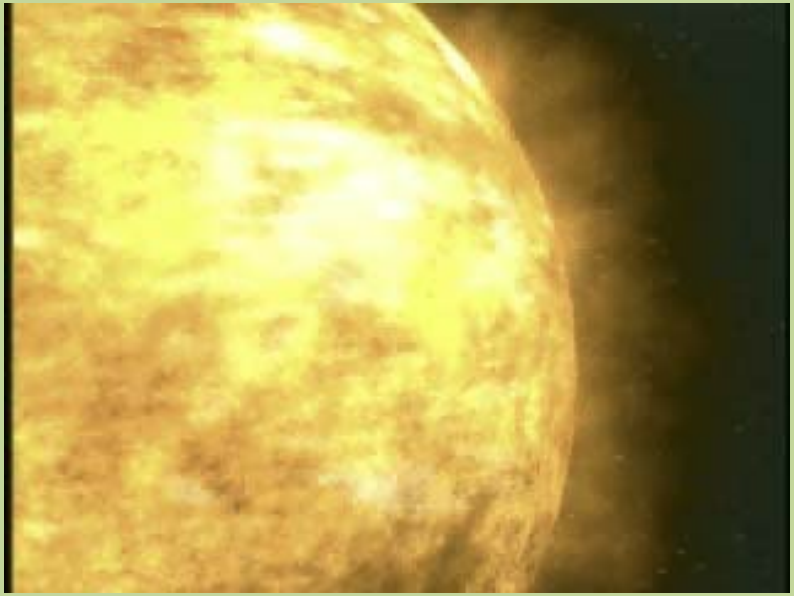
Remote Sensing

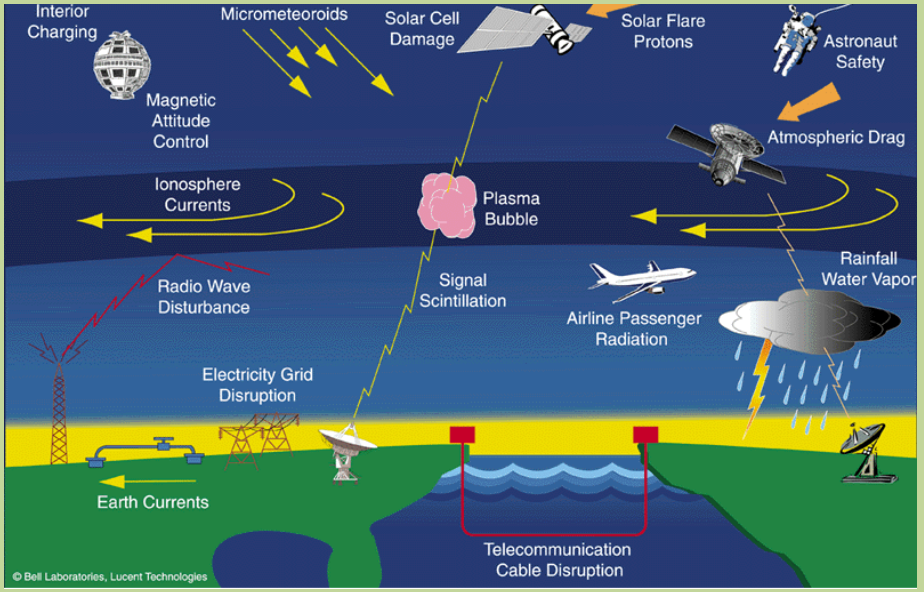
Models and Analysis

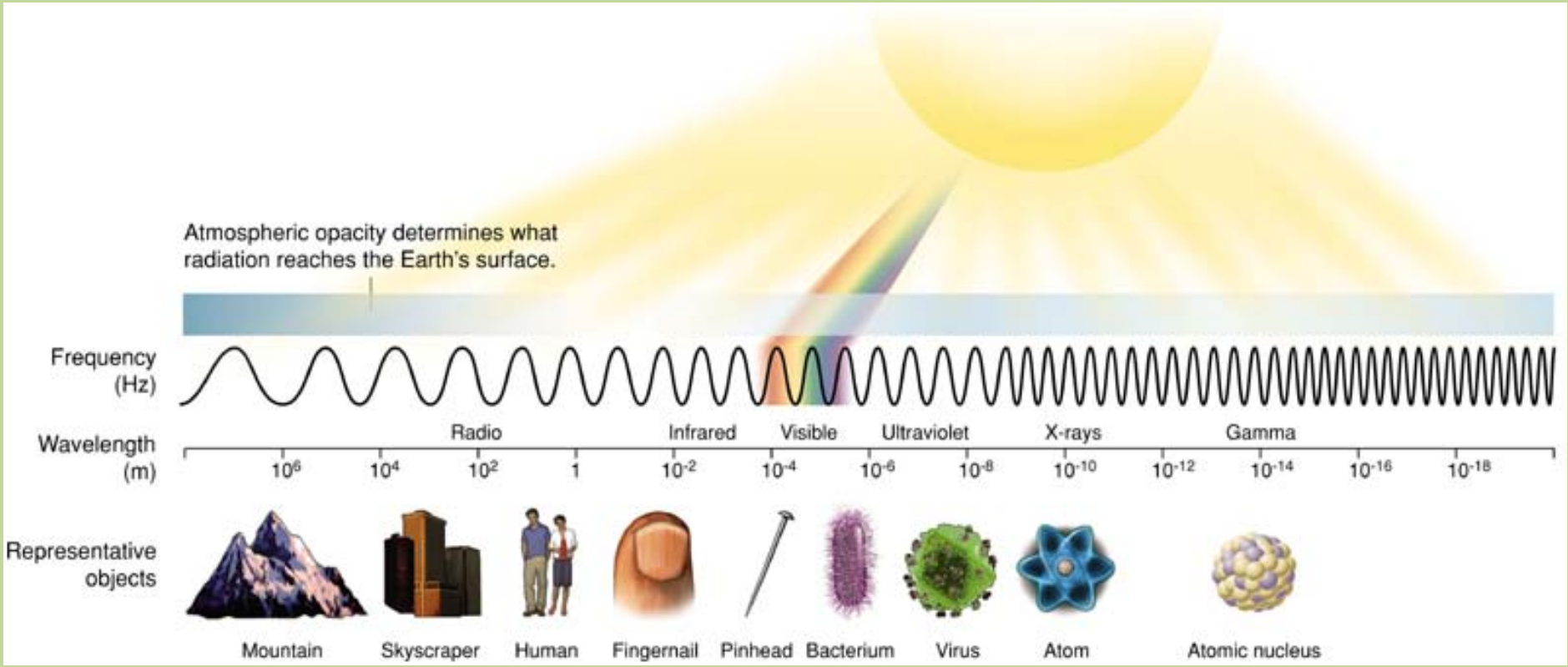
Climate

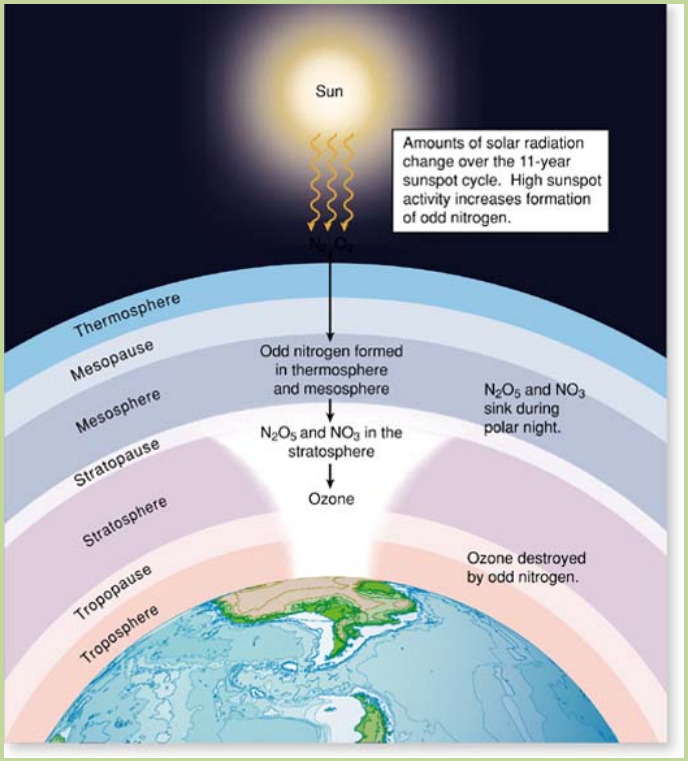
Near-Earth Space Weather Effects

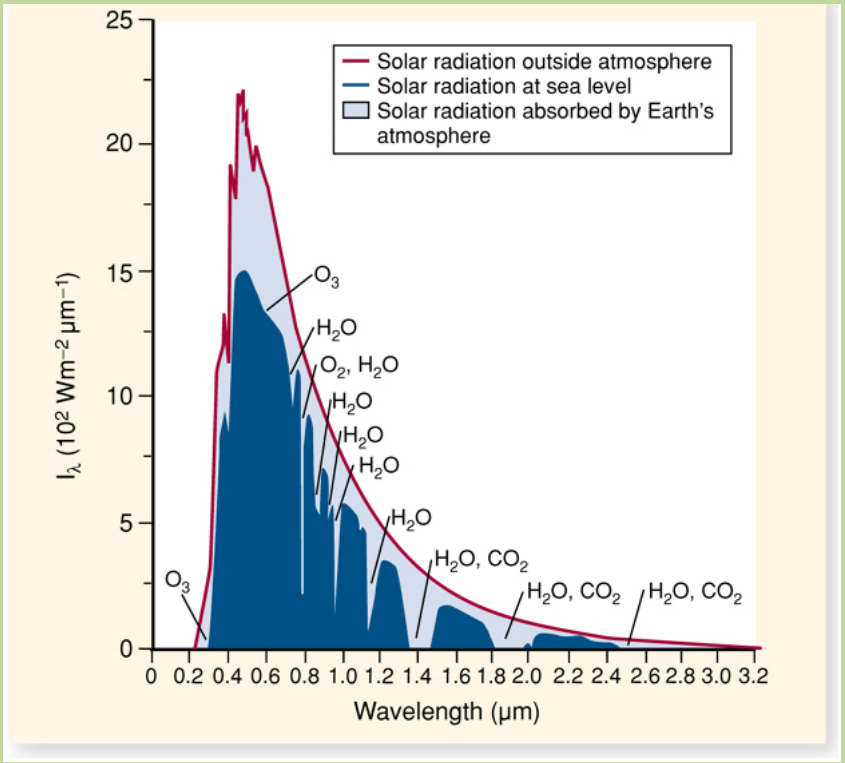


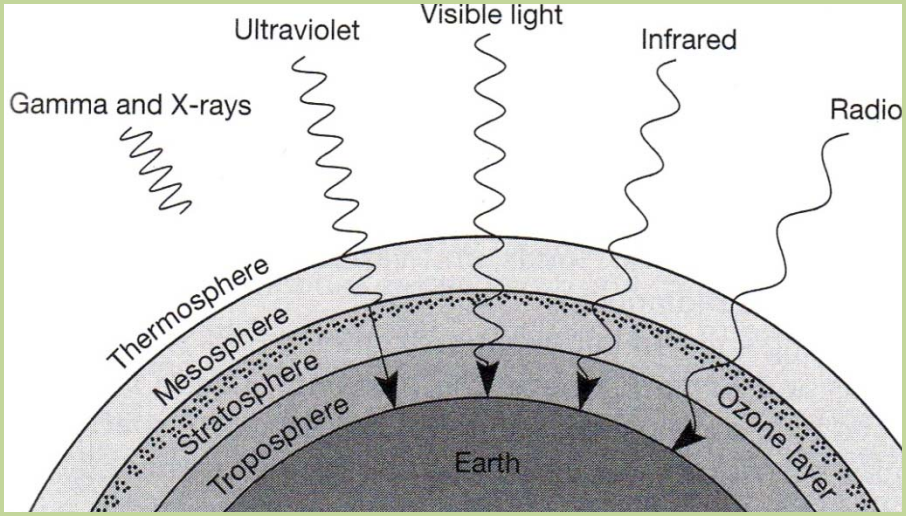




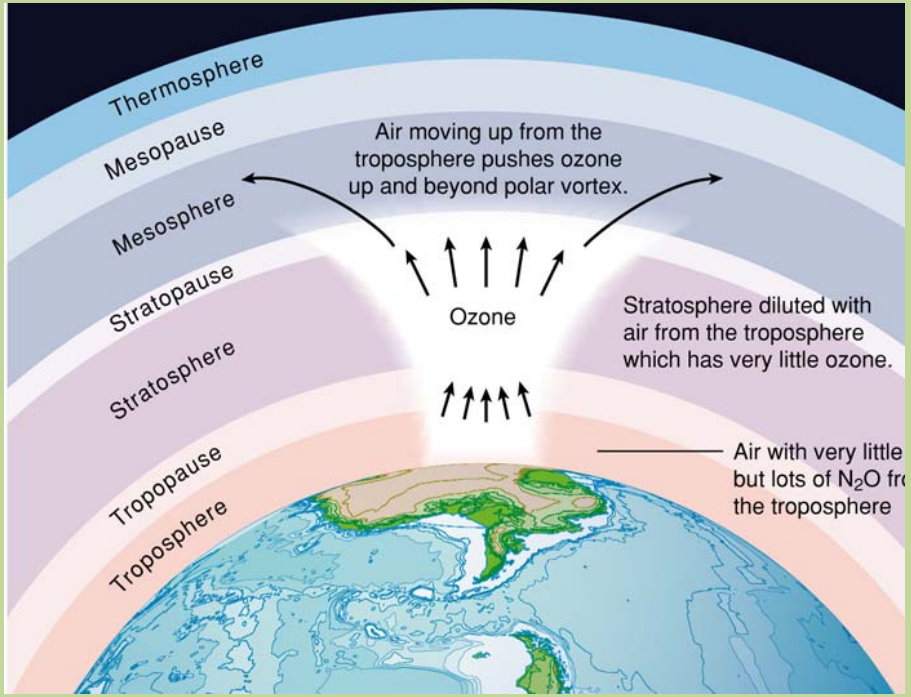

Atmospheric opacity determines what radiation reaches the Earth's surface.
Frequency (Hz)
Wavelength (m)
Radio
Infrared
Visible
Ultraviolet
X-rays
Gamma
10^{6} 10^{4} 10^{2} 1 10^{-2} 10^{-4} 10^{-6} 10^{-8} 10^{-10} 10^{-12} 10^{-14} 10^{-16} 10^{-18}
Representative objects
Mountain
Skyscraper
Human
Fingernail
Pinhead
Bacterium
Virus
Atom
Atomic nucleus

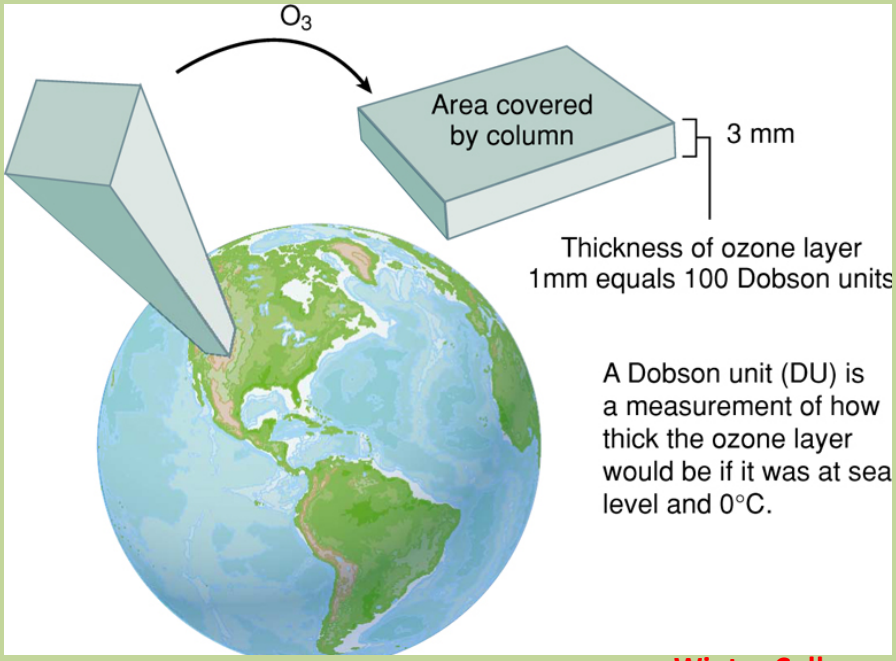


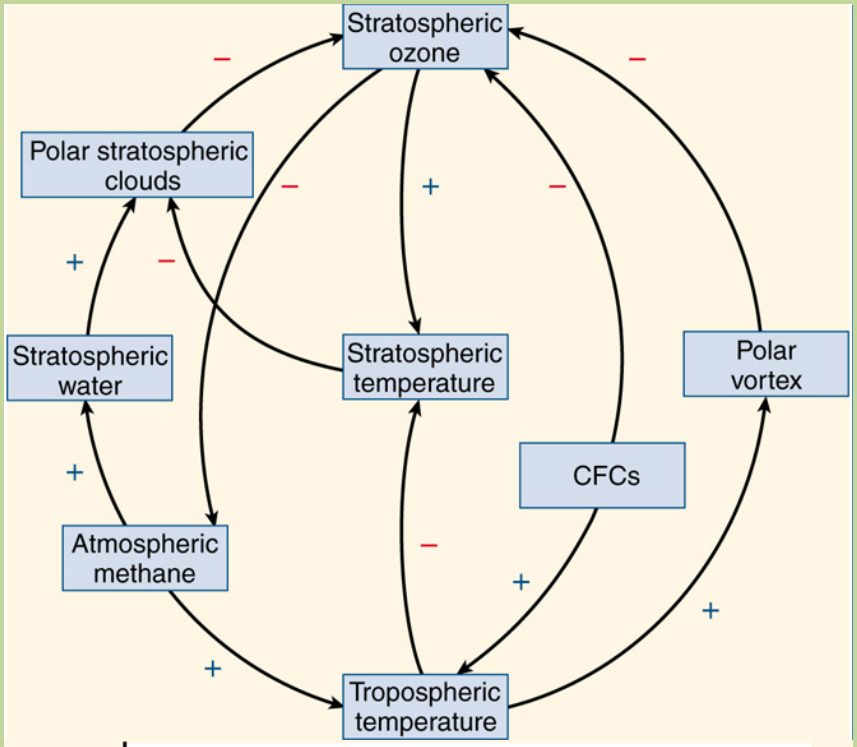


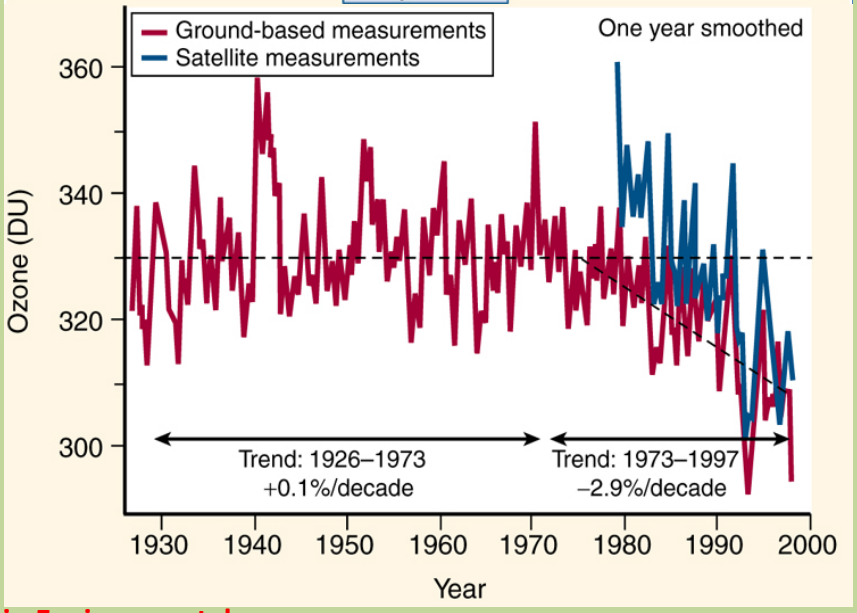


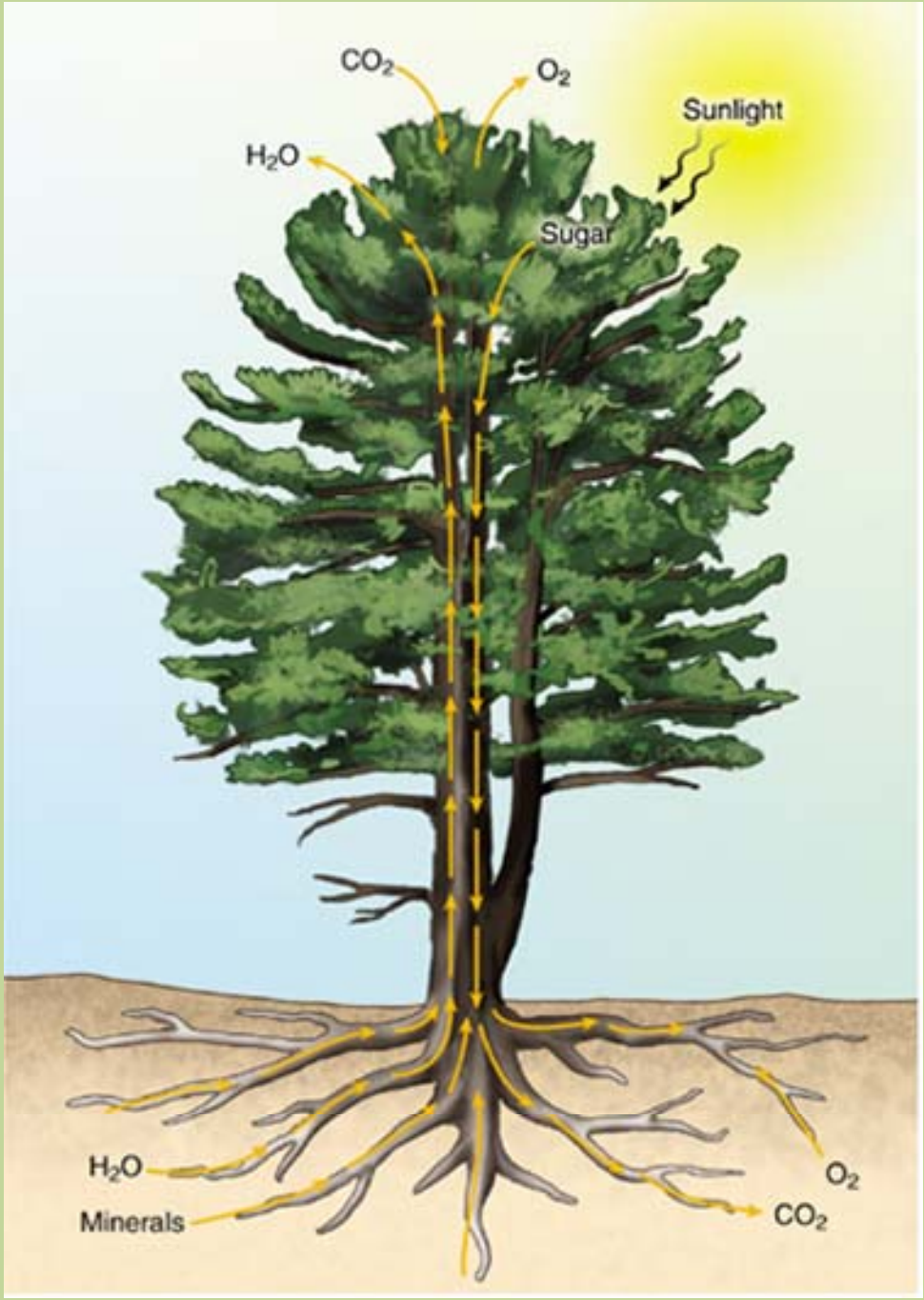
Sun is the source of Electromagnetic Radiations which interact with the Earth and Earth's Atmosphere

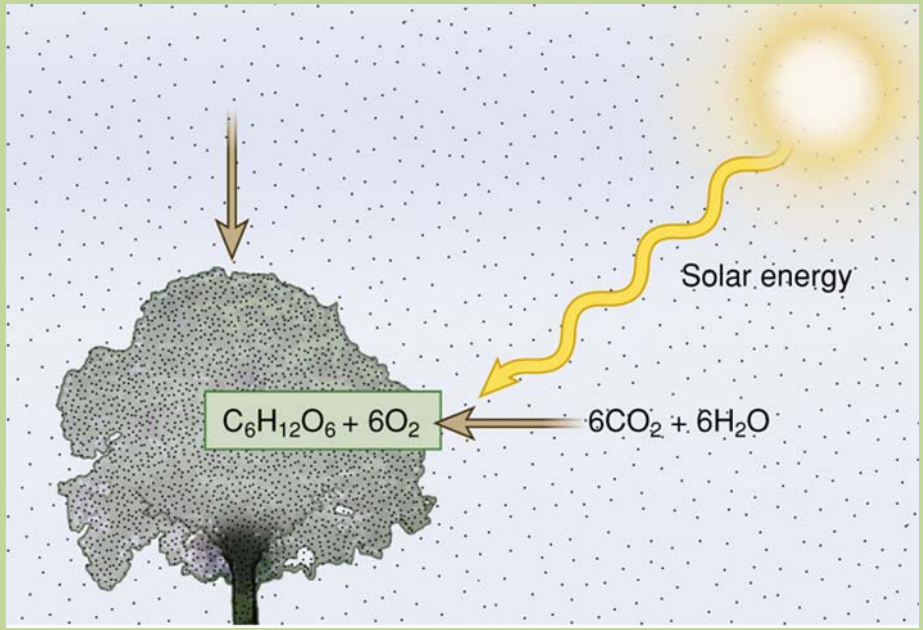

Thermosphere
Mesopause
Mesosphere
Stratopause
Stratosphere
Tropopause
Troposphere
Air moving up from the troposphere pushes ozone up and beyond polar vortex.
Ozone
Stratosphere diluted with air from the troposphere which has very little ozone.
Air with very little
but lots of N_2O fr
the troposphere

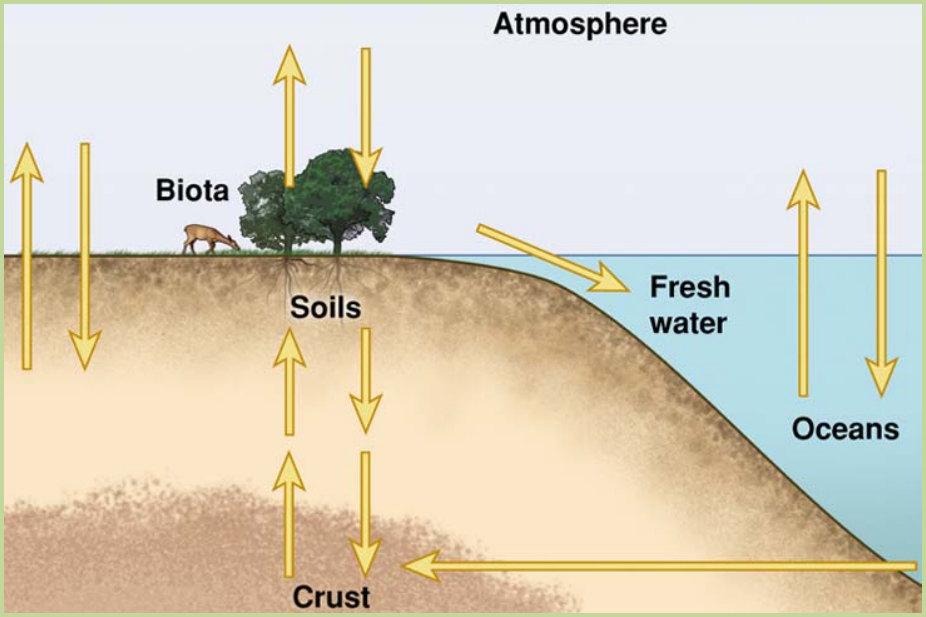

O_3
Area covered by column
3 mm
Thickness of ozone layer
1mm equals 100 Dobson units
A Dobson unit (DU) is a measurement of how thick the ozone layer would be if it was at sea level and 0°C.

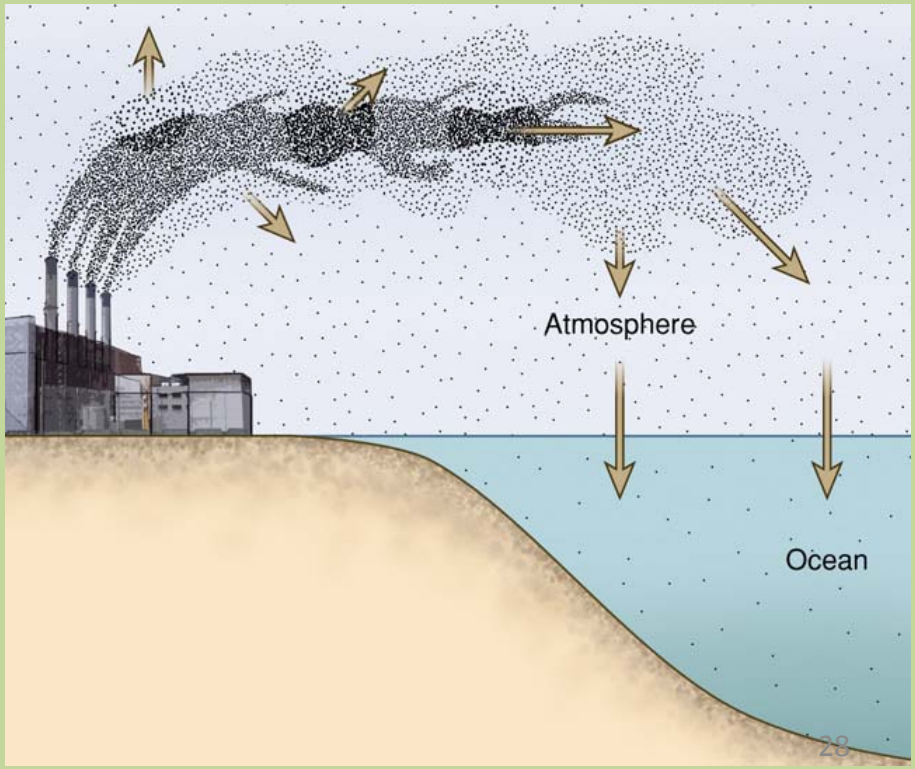

Stratospheric ozone
Polar stratospheric clouds
Stratospheric water
Stratospheric temperature
Polar vortex
CFCs
Atmospheric methane
Tropospheric temperature

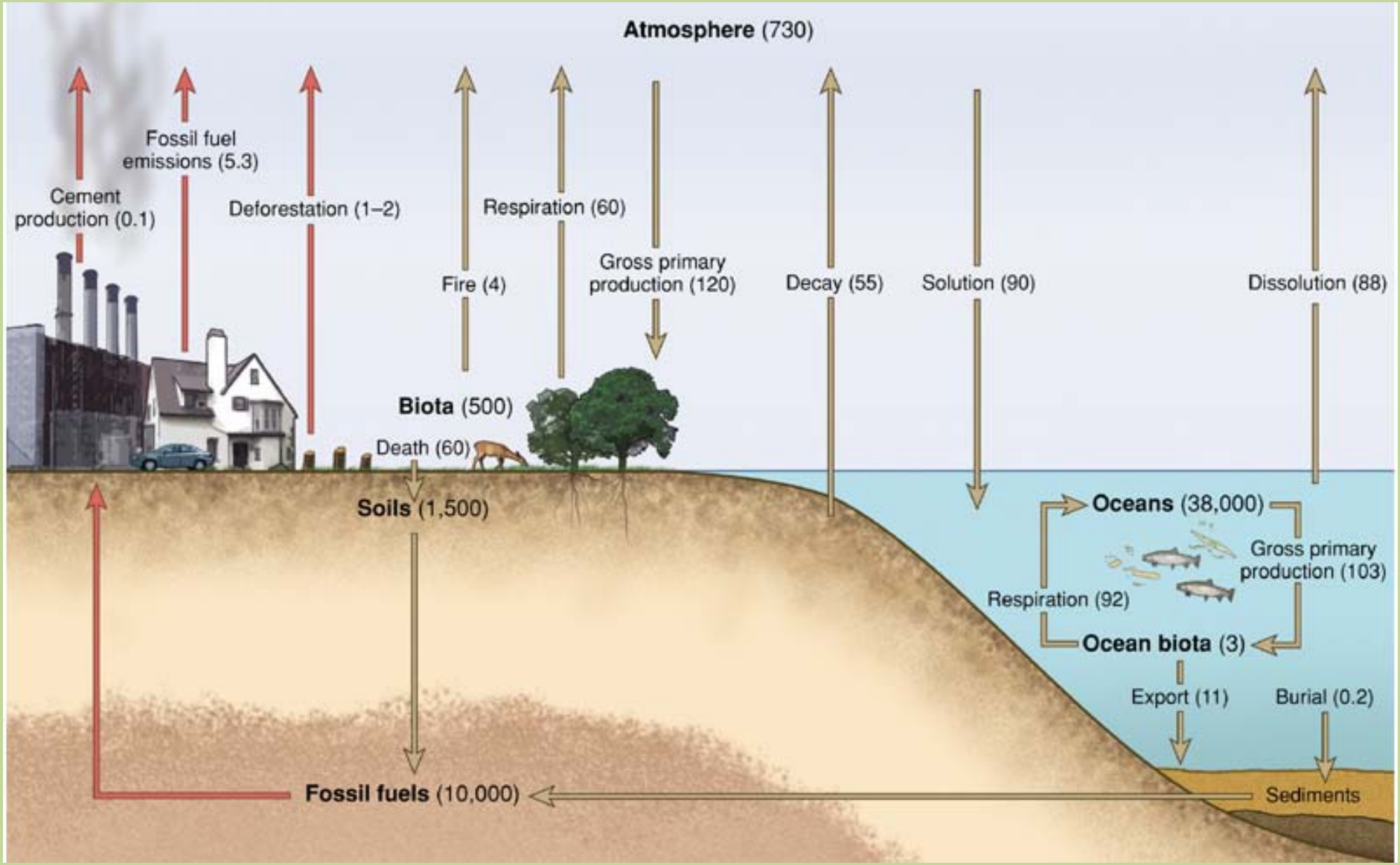

Ground-based measurements
Satellite measurements
One year smoothed
Ozone (DU)
360
340
320
300
Trend: 1926–1973
+0.1%/decade
Trend: 1973–1997
–2.9%/decade
1930
1940
1950
1960
1970
1980
1990
2000
Year

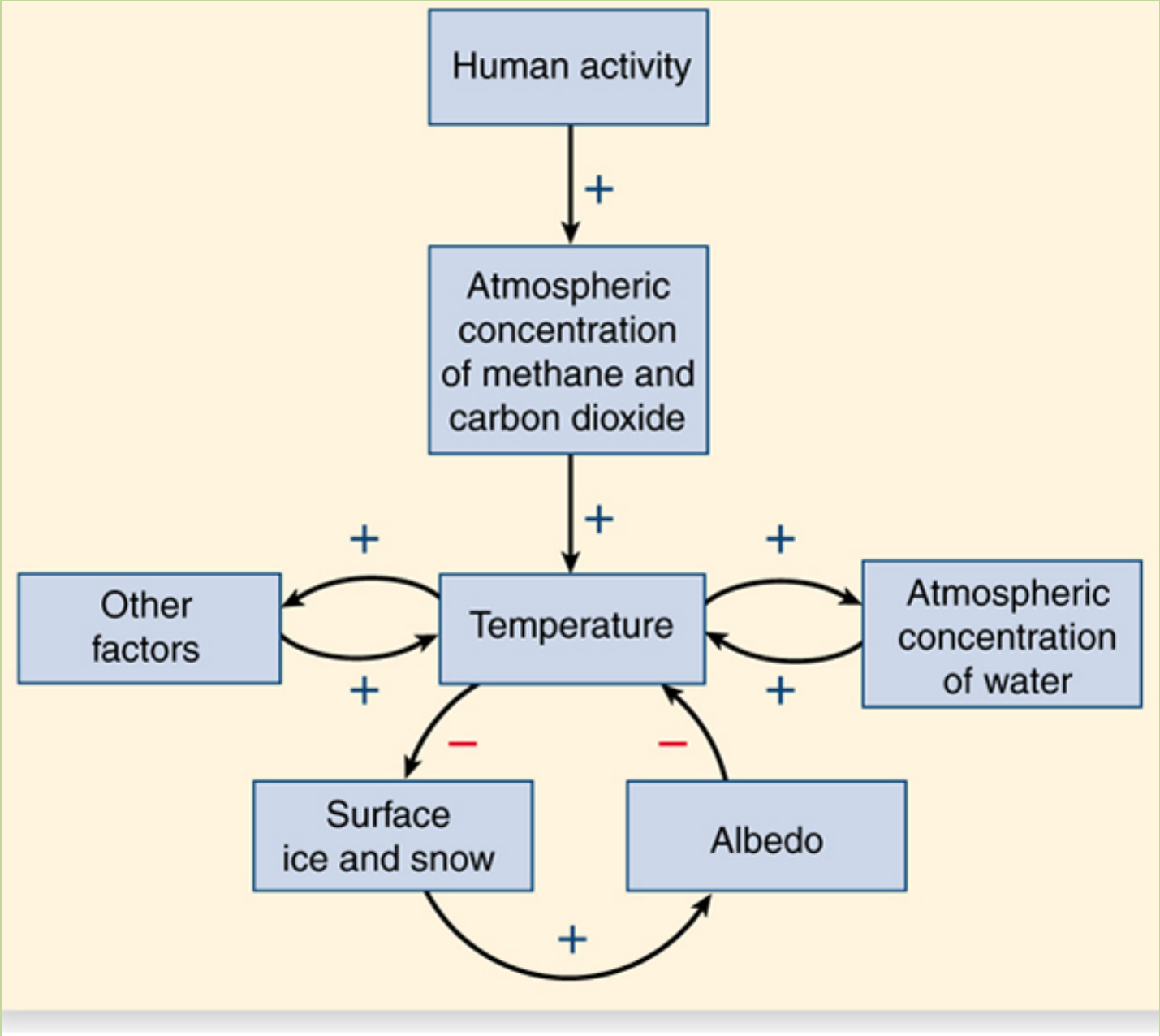

CO_2
O_2
Sunlight
H_2O
Sugar
H_2O
Minerals
O_2
CO_2

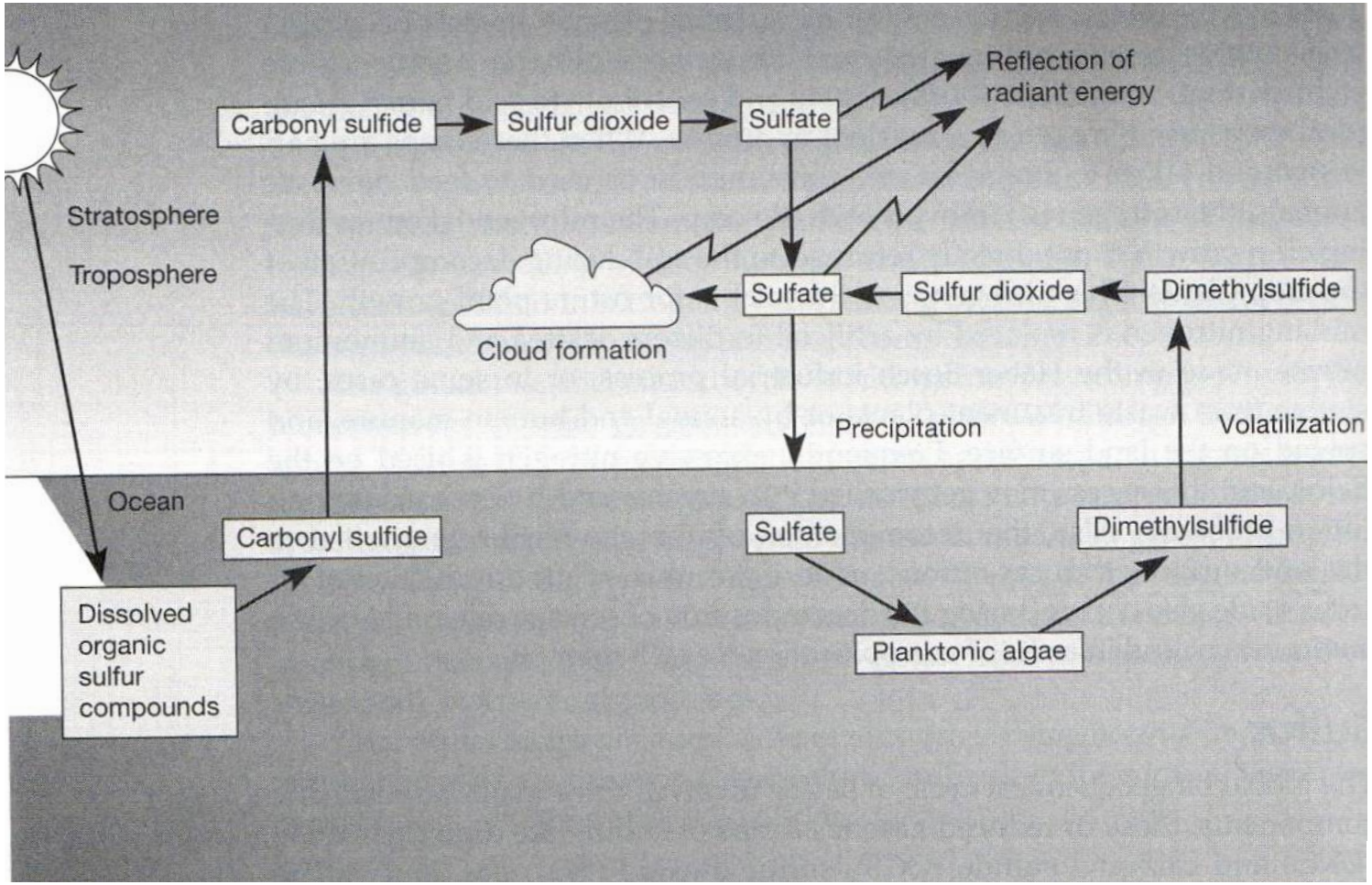

Solar energy
$C_6H_{12}O_6 + 6O_2$
$6CO_2 + 6H_2O$

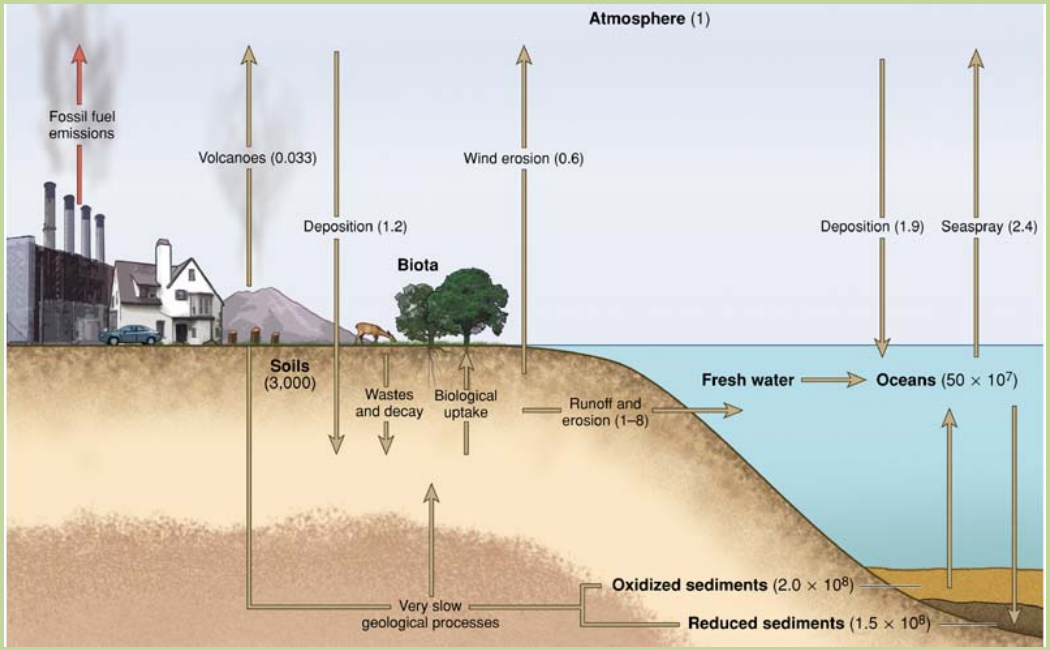

Atmosphere
Biota
Soils
Fresh
water
Oceans
Crust

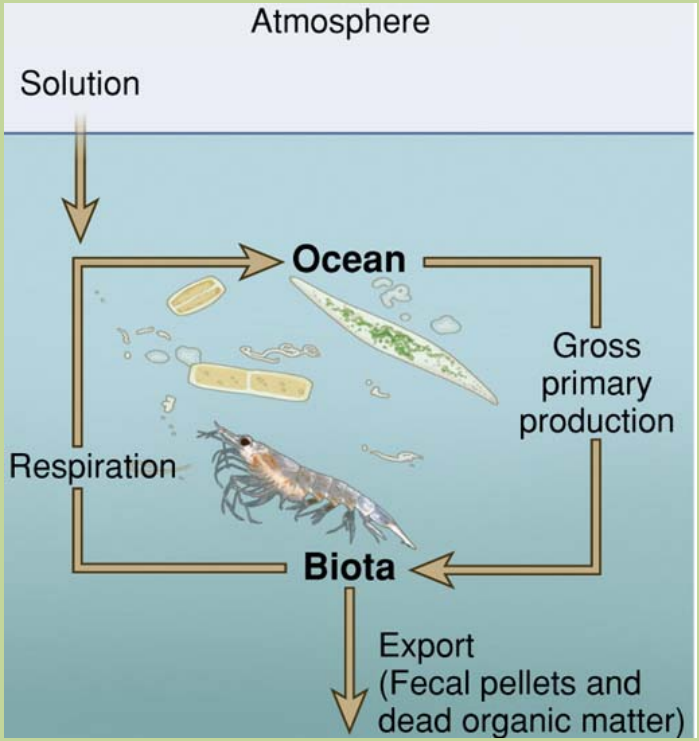

Atmosphere
Ocean


Atmosphere (730)
Fossil fuel emissions (5.3)
Cement production (0.1)
Deforestation (1–2)
Respiration (60)
Fire (4)
Gross primary production (120)
Decay (55)
Solution (90)
Dissolution (88)
Biota (500)
Death (60)
Soils (1,500)
Oceans (38,000)
Gross primary production (103)
Respiration (92)
Ocean biota (3)
Export (11)
Burial (0.2)
Fossil fuels (10,000)
Sediments


Human activity
+
Atmospheric concentration of methane and carbon dioxide
+
+
+
Other factors
Temperature
Atmospheric concentration of water
+
+
−
−
Surface ice and snow
Albedo
+

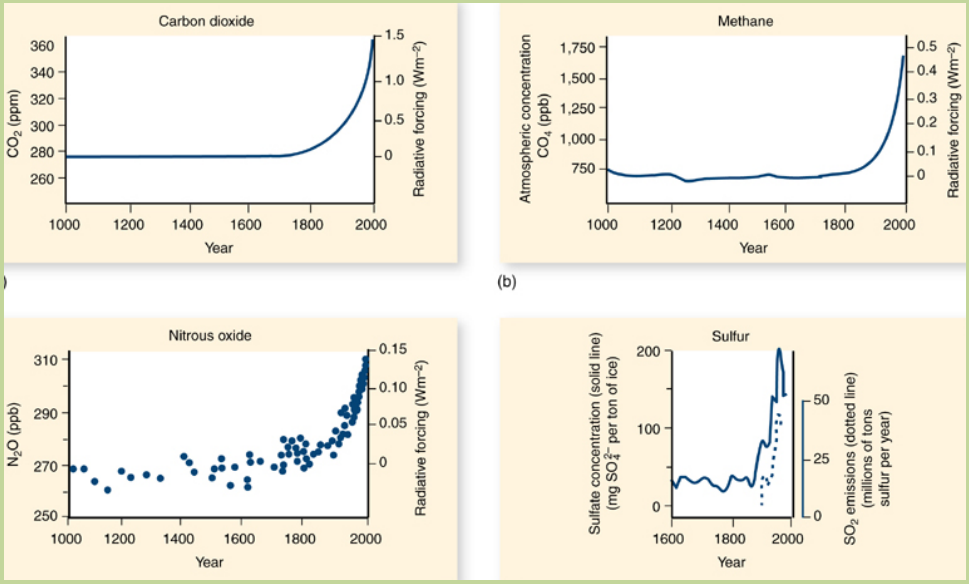

Carbonyl sulfide
Sulfur dioxide
Sulfate
Reflection of radiant energy
Stratosphere
Troposphere
Cloud formation
Sulfate
Sulfur dioxide
Dimethylsulfide
Precipitation
Volatilization
Ocean
Carbonyl sulfide
Sulfate
Dimethylsulfide
Dissolved organic sulfur compounds
Planktonic algae


Atmosphere (1)
Fossil fuel emissions
Volcanoes (0.033)
Deposition (1.2)
Wind erosion (0.6)
Biota
Deposition (1.9)
Seaspray (2.4)
Soils (3,000)
Wastes and decay
Biological uptake
Runoff and erosion (1–8)
Fresh water
Oceans (50×10^7)
Oxidized sediments (2.0×10^8)
Very slow geological processes
Reduced sediments (1.5×10^8)

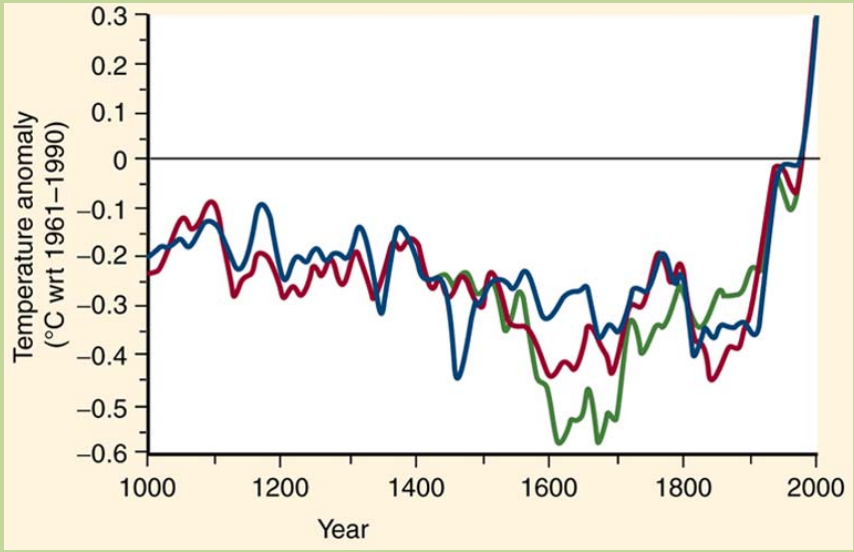

Atmosphere
Solution
Ocean
Gross primary production
Respiration
Biota
Export (Fecal pellets and dead organic matter)

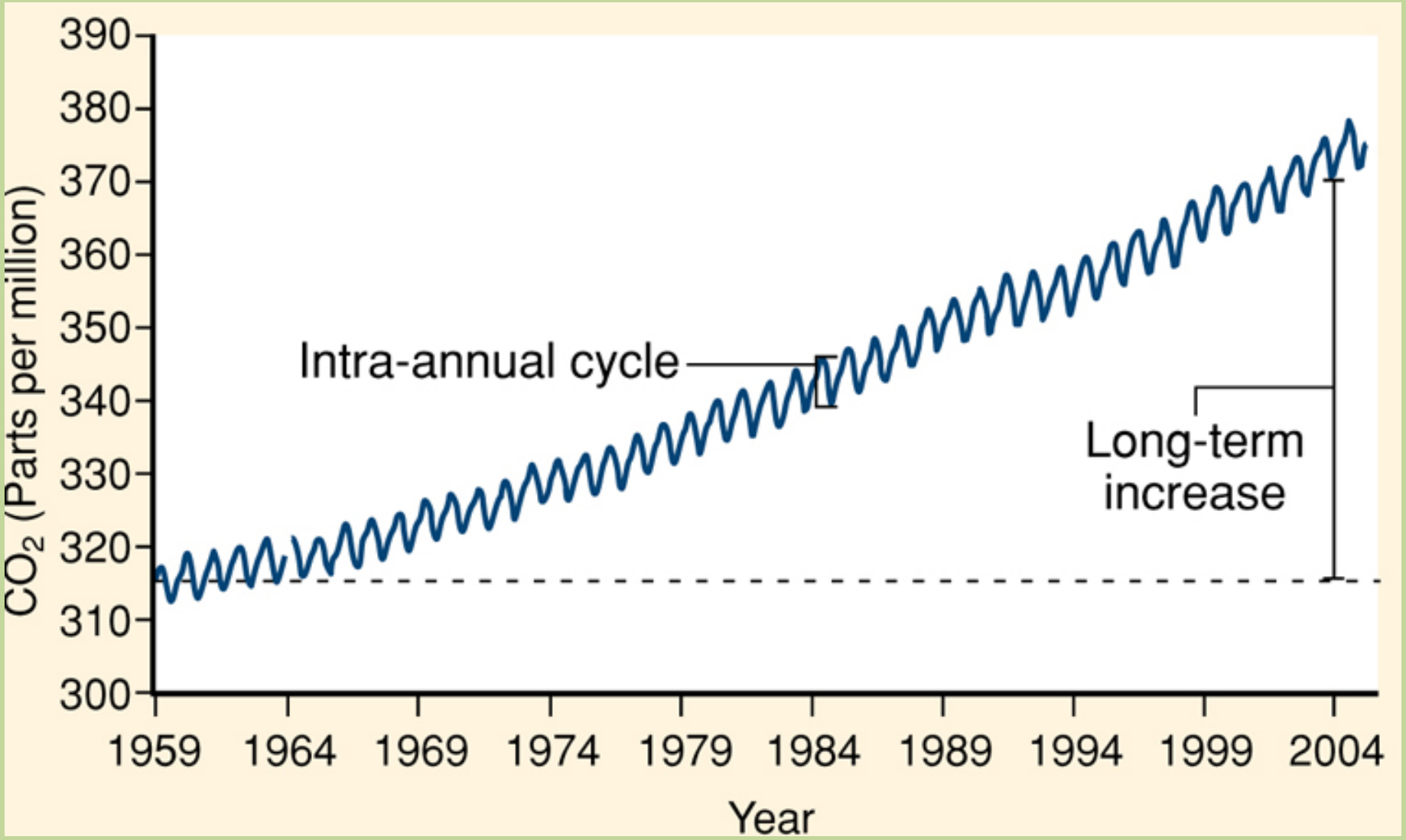
Human conducting an uncontrolled experiment

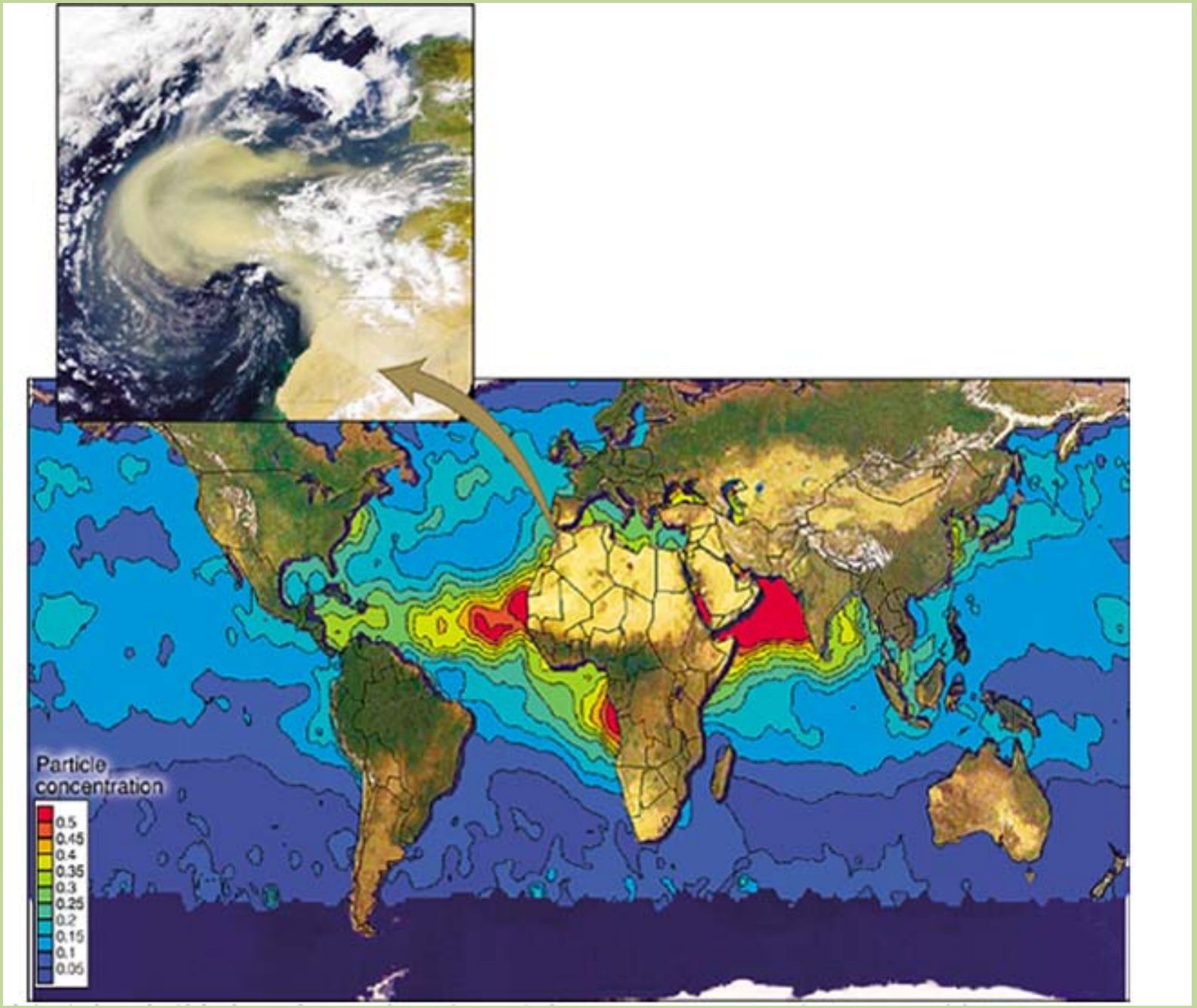
- **Greenhouse gases are natural:**
  - **H_2O, CO_2, CH_4, . . .**
- **Humans add more greenhouse gases**
- **These gases are warming the Earth**



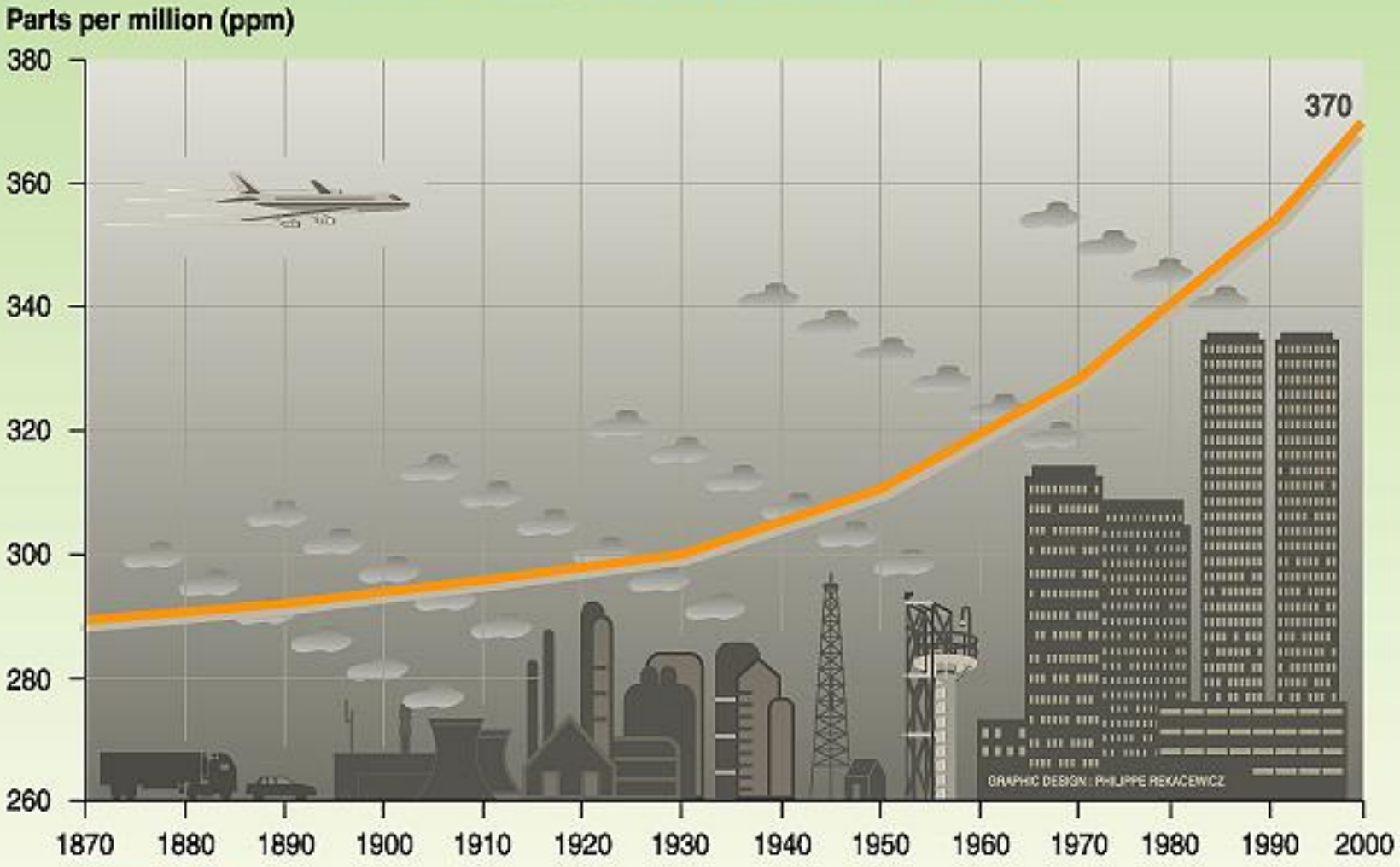
See the Increasing trend of temperature?




390
380
370
360
350
340
330
320
310
300
CO_2 (Parts per million)
Intra-annual cycle
Long-term increase
1959
1964
1969
1974
1979
1984
1989
1994
1999
2004
Year


Particle
concentration
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05

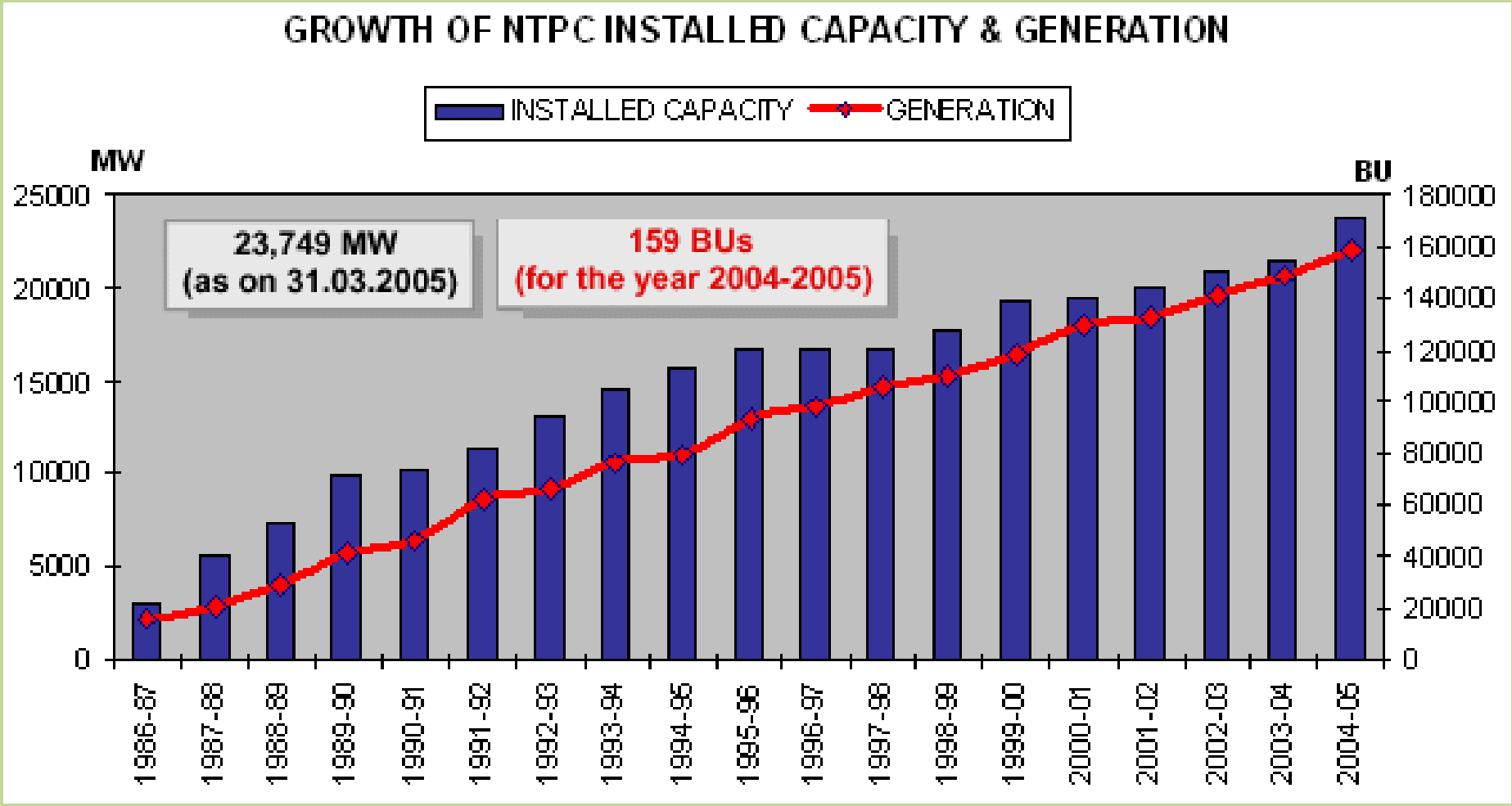
Global atmospheric concentration of CO_2



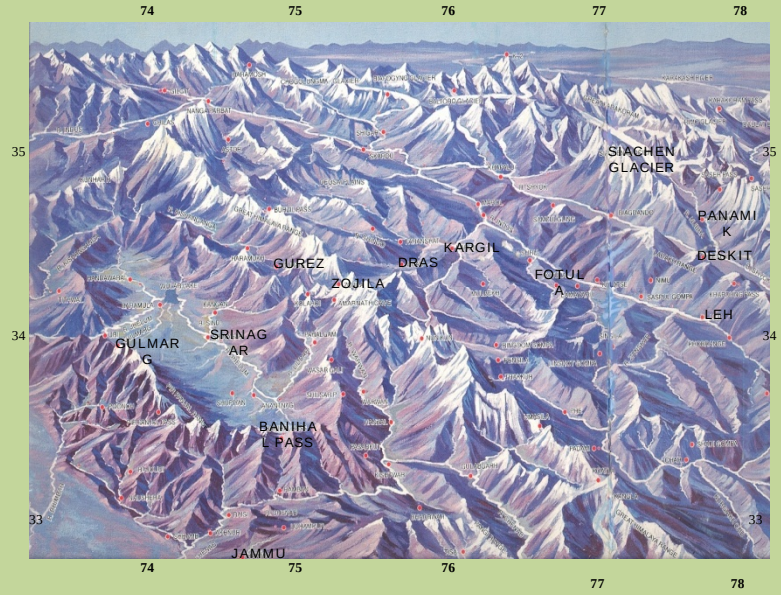
GRID Arendal UNEP

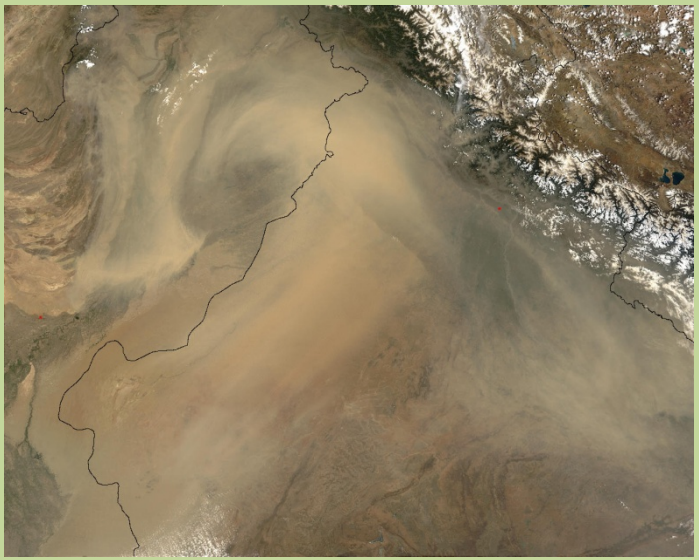
Winter College on Optics in Environmental Science,
ICTP, Trieste Feb. 2-13, 2009

Sources: TP Whorf Scripps, Mauna Loa Observatory, Hawaii, institution of oceanography (SIO), university of California La Jolla, California, United States, 1999


GROWTH OF NTPC INSTALLED CAPACITY & GENERATION
INSTALLED CAPACITY
GENERATION
MW
BU
25000
20000
15000
10000
5000
0
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
23,749 MW
(as on 31.03.2005)
159 BUs
(for the year 2004-2005)
1986-87
1987-88
1988-89
1989-90
1990-91
1991-92
1992-93
1993-94
1994-95
1995-96
1996-97
1997-98
1998-99
1999-00
2000-01
2001-02
2002-03
2003-04
2004-05

Panoramic View of Himalaya





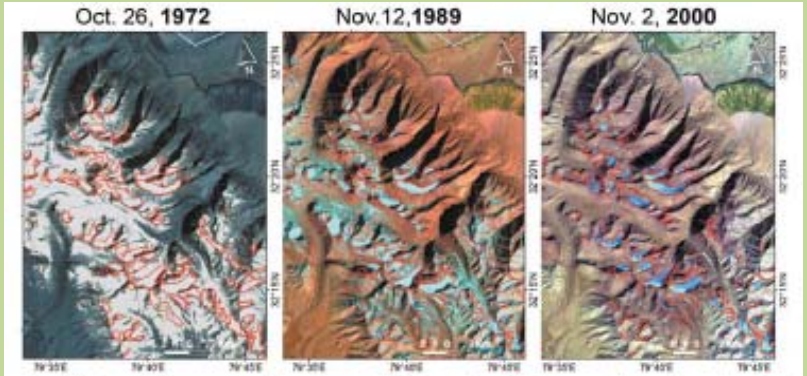


Fig. 1. Change in the snow and glacier cover in the western Himalayan region as shown in Landsat multispectral scanner (1972), thematic mapper (1989), and Enhanced Thematic Mapper Plus (2000) images. Areas outlined in red indicate information from the GLIMS database.

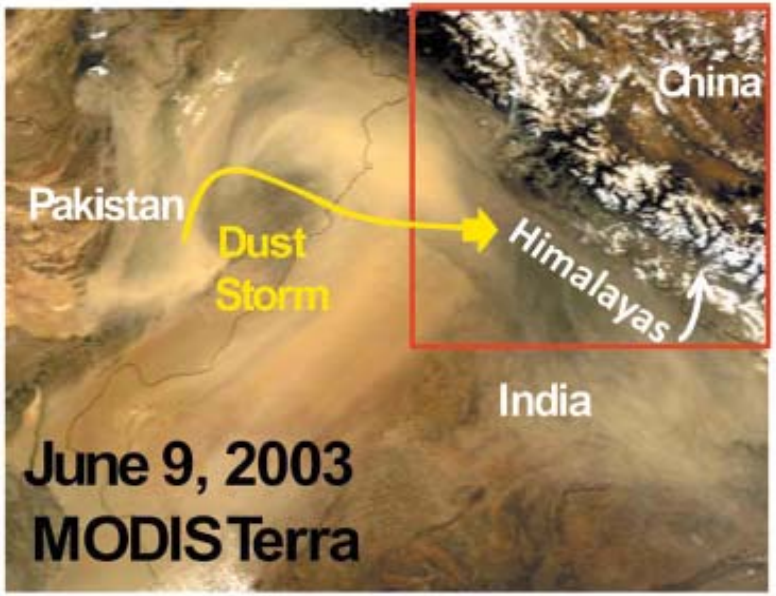
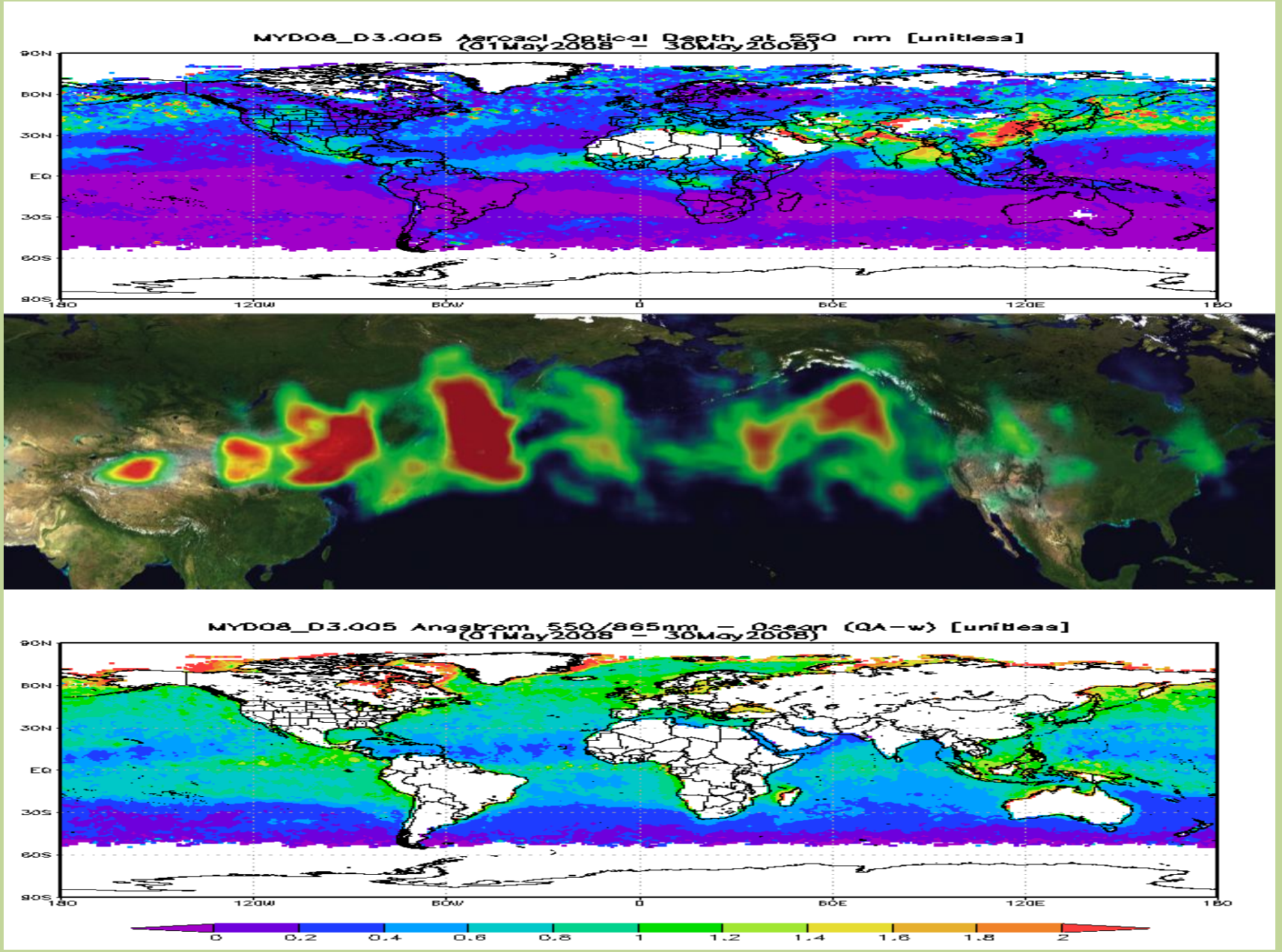
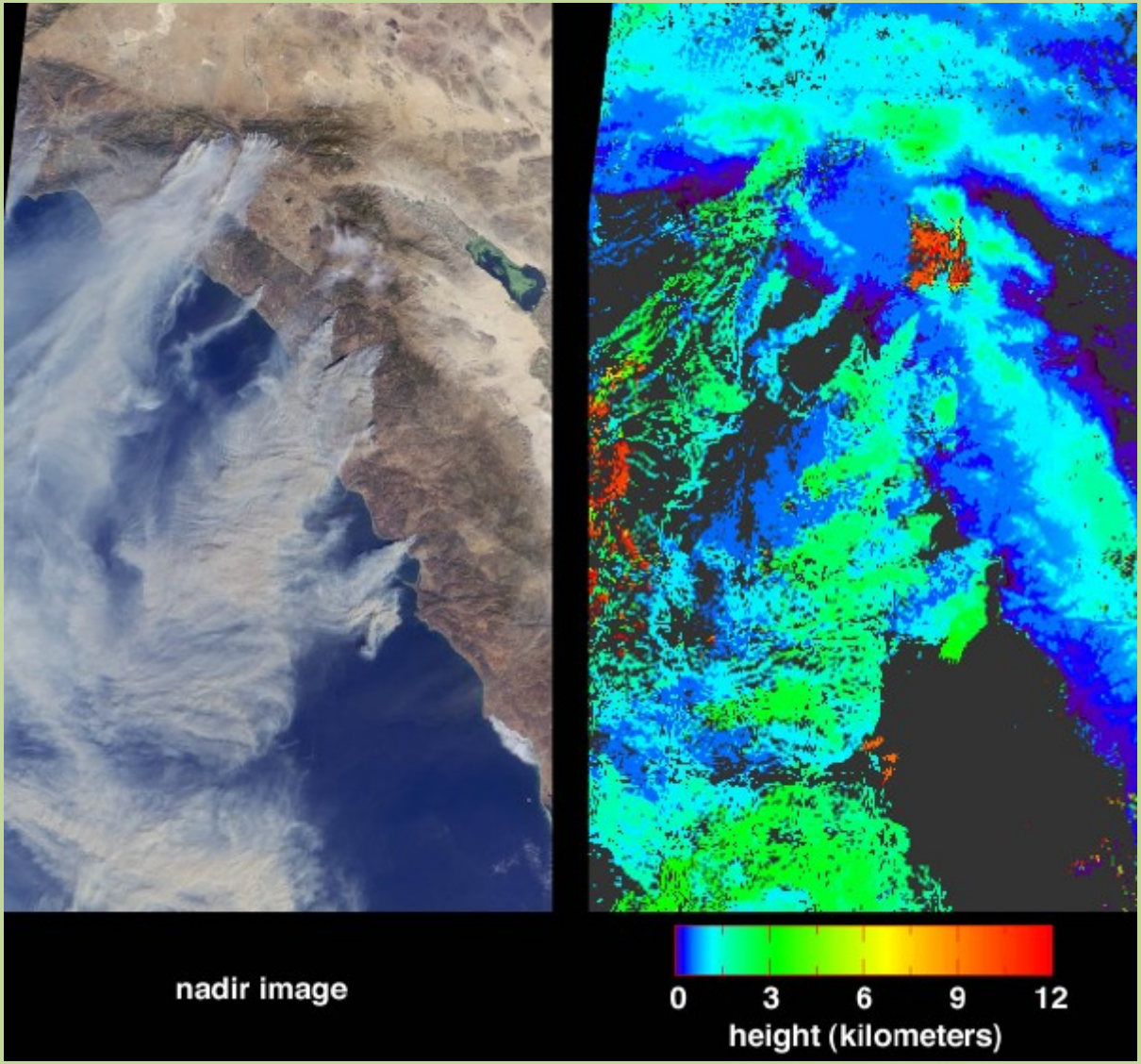


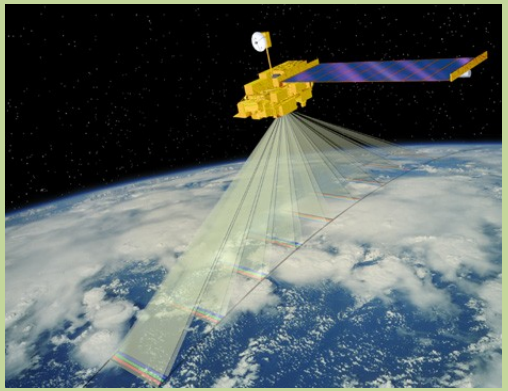
Fig. 2. Dust storms reach up to snow and glacier of Himalayas (box outlined in red) as visible in this 9 June 2003 MODIS Terra image obtained from the MODIS Web site (http://modis.gsfc.nasa.gov/).

Singh et al., 2007, EOS


MYD08_D3.005 Aerosol Optical Depth at 550 nm [unitless]
(01May2008 – 30May2008)
90N
60N
30N
EQ
30S
60S
90S
180
120W
60W
0
60E
120E
180
MYD08_D3.005 Angstrom 550/865nm – Ocean (QA=w) [unitless]
(01May2008 – 30May2008)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2

Wildfires

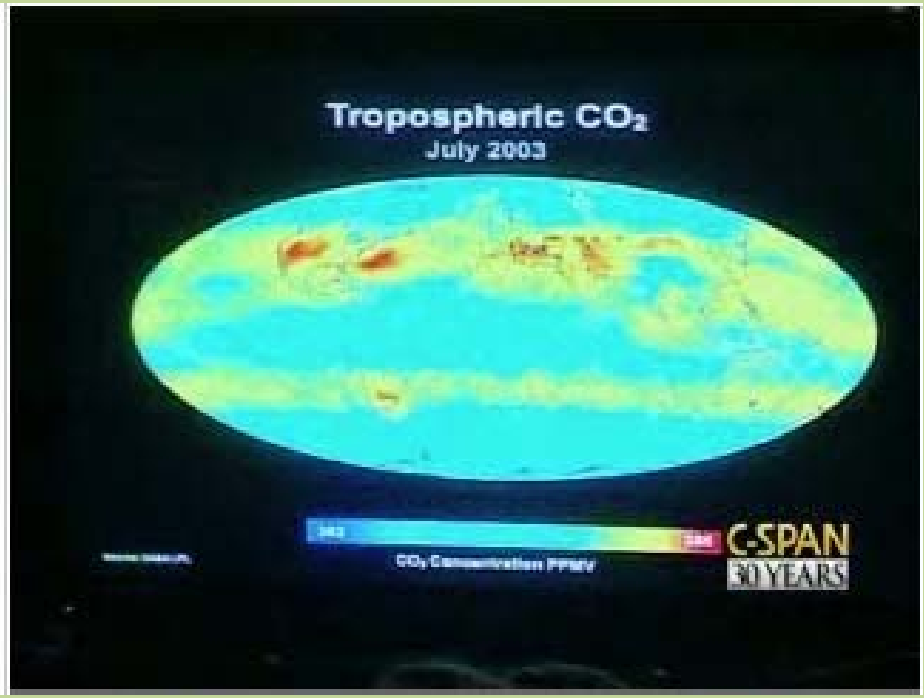


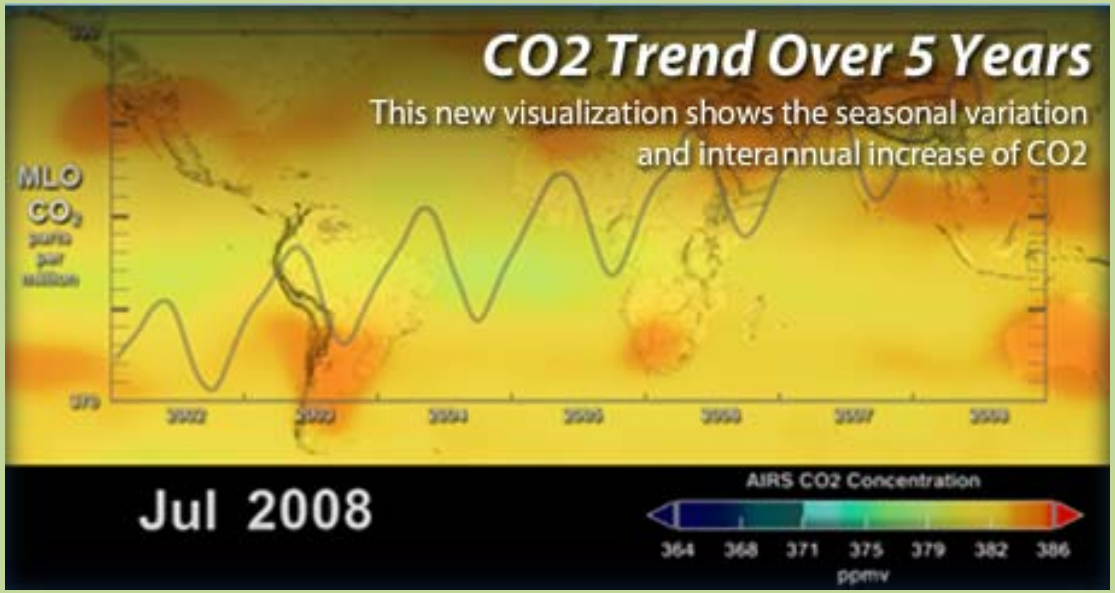


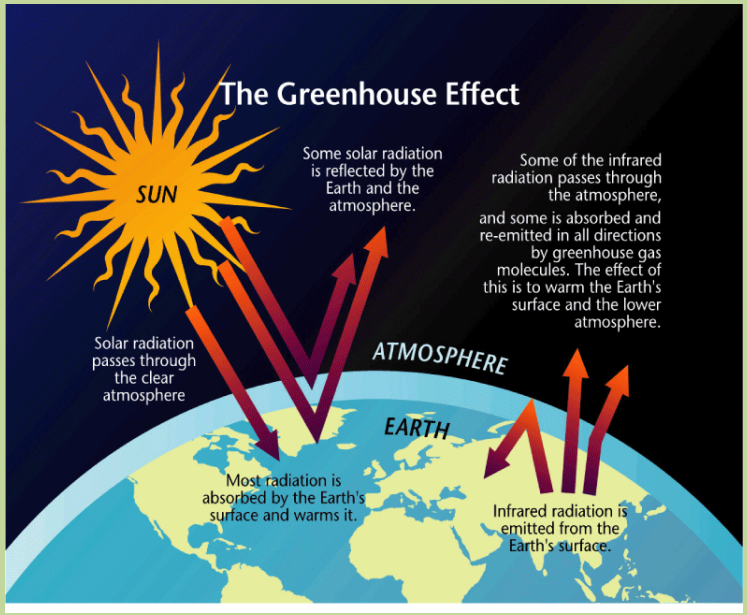
Wildfires Rage in Southern California October 26, 2003
(MISR image)

Source: http://eosweb.larc.nasa.gov

http://airs.jpl.nasa.gov/







Waning woods

Science **323**, 521–524 (2009)

Trees in western North America are dying more quickly than they used to, but there is no corresponding increase in the number of new seedling trees. Mortality rates, which are currently of the order of 1% a year, have in many cases doubled in just a couple of decades.

The trend was picked out by a group led by Phillip van Mantgem and Nathan Stephenson, both then based at the US Geological Survey Western Ecological Research Center in Three Rivers, California. The increased mortality correlates with climate change in the region, which has warmed by an average of between 0.3 and 0.4 °C per decade since the 1970s.

Areas Impacting Society

Natural Disasters

Agriculture

Water Management

Weather

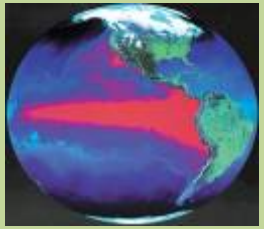
Ecosystems

Air Quality

Public Health

Extreme case

Can turn into a Disastrous situation



Climate

Study of Environmental and its management is important, why?

*Air we breath

*Water we drink

*Food we eat

Water

- Pollution of Water Gathering Ground
- Pollution of River
- Recovery of River
- Conservation on the use of water
- Abuse of water : for holding seafood
- For swimming

Air

***Outdoor area air quality monitoring**

***Power generation and air pollution**

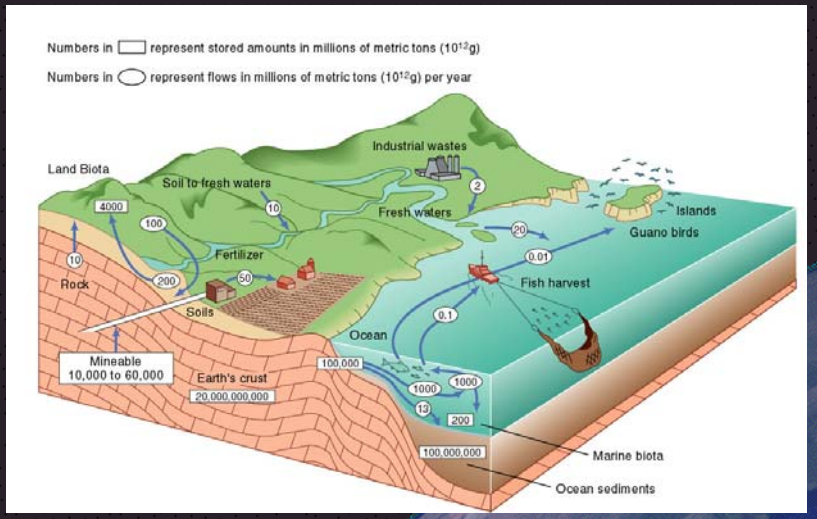
***Transport and air pollution**

***Indoor area : No smoking areas**

***Toxic gases from household products**

***Explosive gases in cargo container**

Environmental Science Related Questions



How does the Earth work?

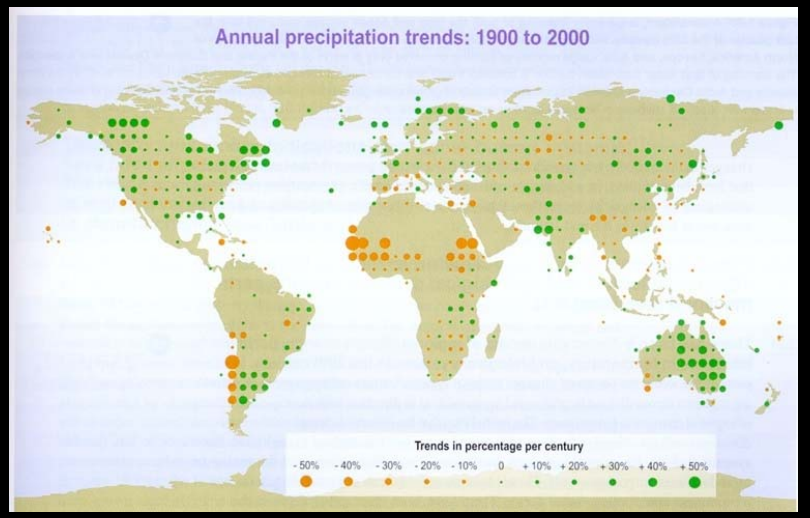
How is the Earth changing?

Are human activities sufficiently strong to alter the chemical composition of the planet, to overcome natural forces and drive it towards a warmer climate?

How does our changing environment affect life on Earth?

Affecting Monsoon and Rainfall

We must learn how to conserve water !



- Change in Program

  Today
- 18.00 - 19.00 Capacity building in Satellite data analysis and visualization for ecosystem monitoring

  - Ashbindu Singh (UNEP)