Unit 4: Major Environmental Issues

Global Climate Change

Summary

Introduction-some facts

Historical climate data

Global Temperature Models

The Greenhouse effect

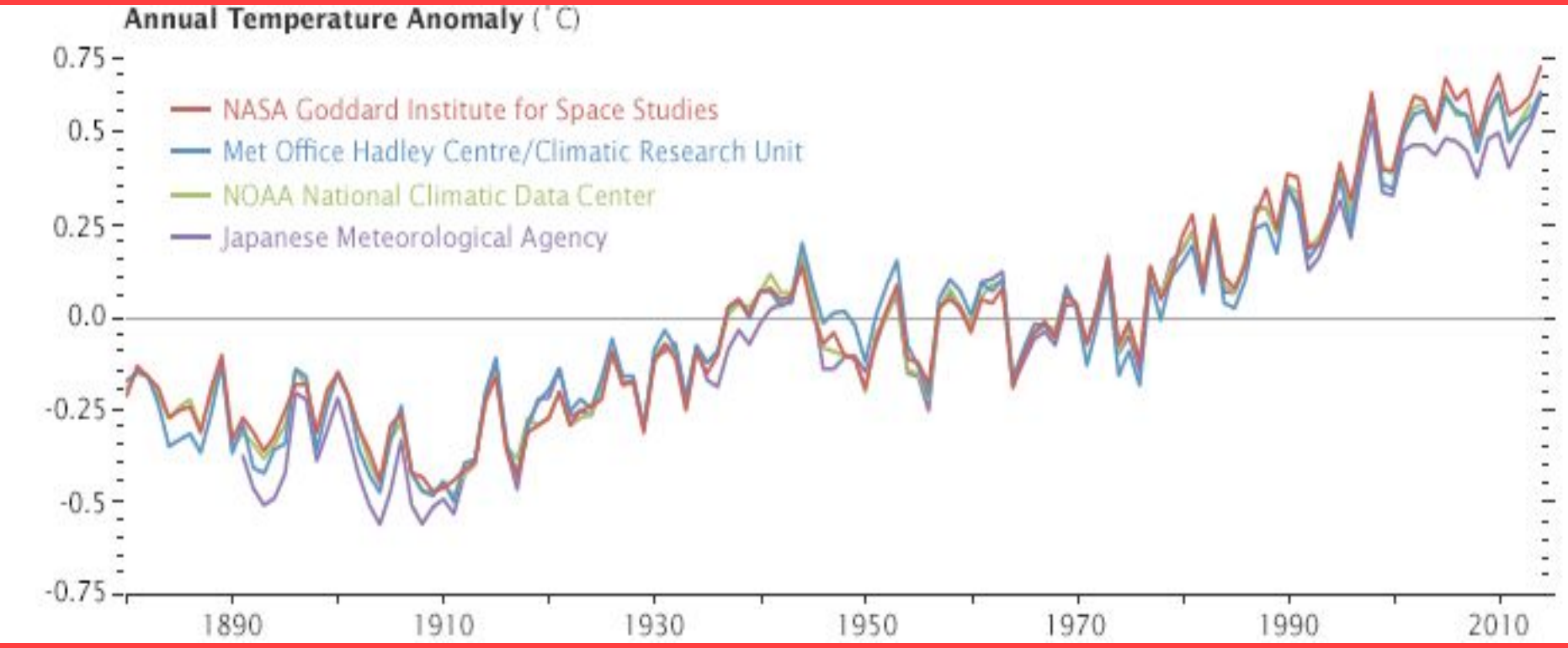
Global warming

Climate Change initiatives

Case studies- Climate Change

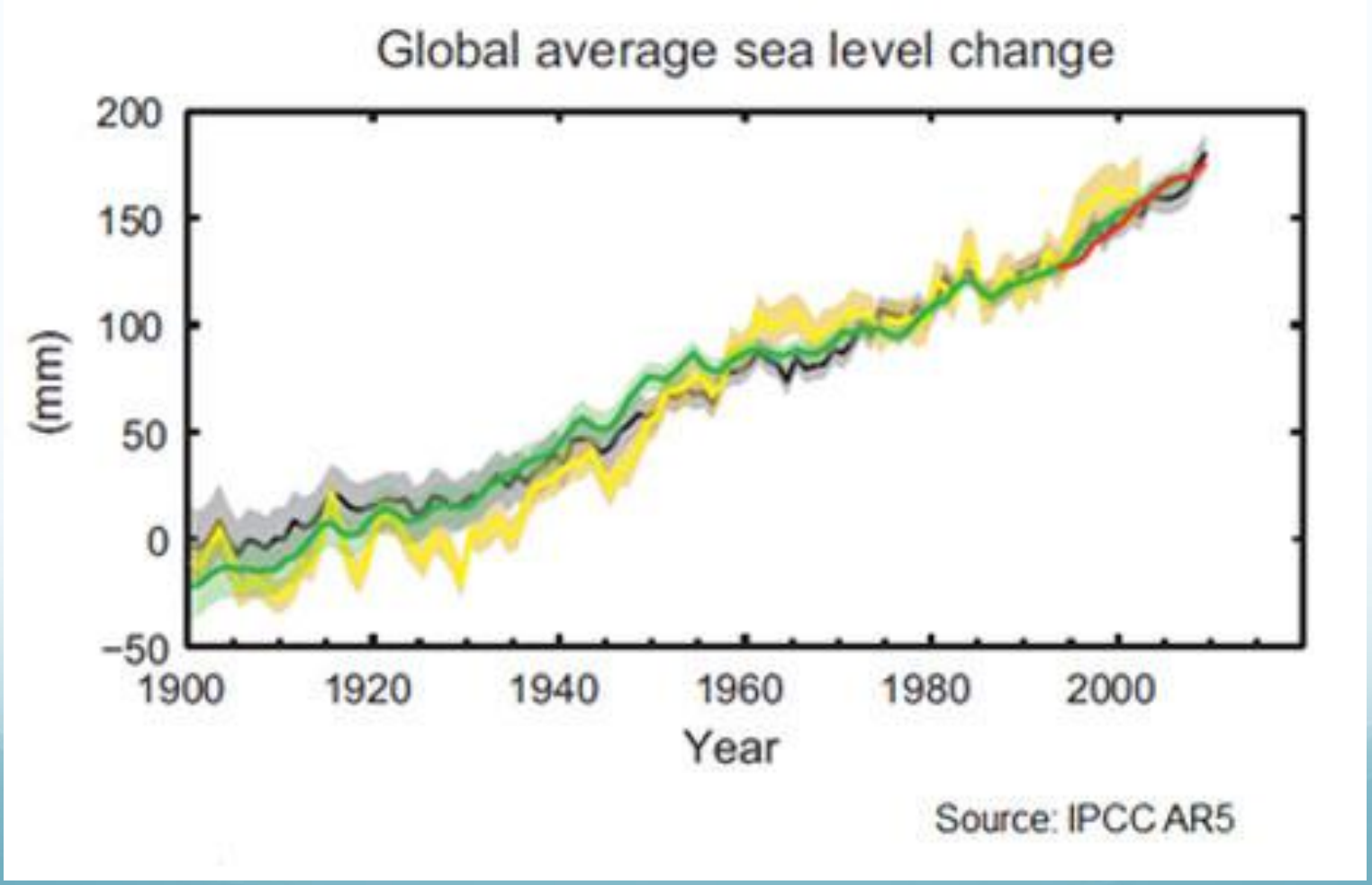
Some Facts…

The global average surface temperature has increased over the 20th century by about 0.6°C (IPCC).



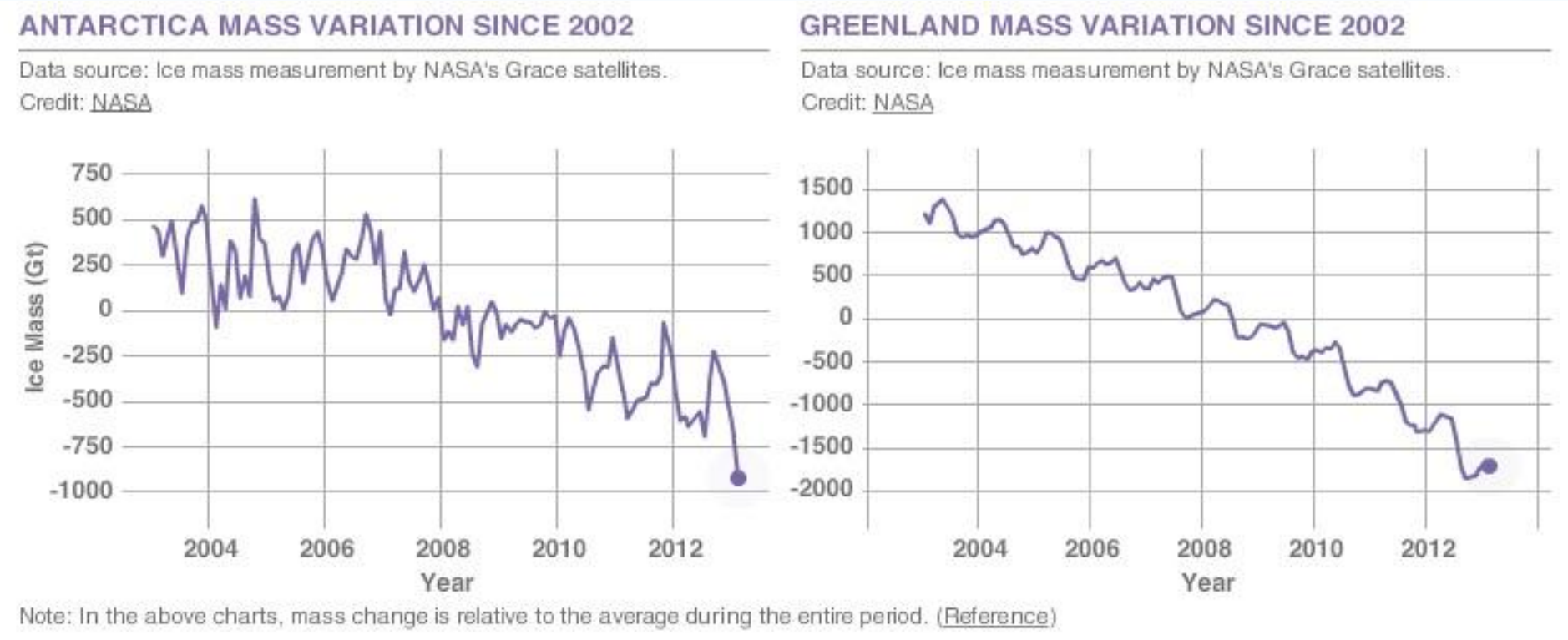
Some Facts…

The global average sea level rose by 0.19 m (IPCC)



Some Facts…

There is a significant reduction in glacial mass in poles.



An iceberg of the size of the state of Delaware split off from Antarctica's Larsen C ice shelf- NASA reported on 12 July 2017

Who updates the climate information?

- **Meteorological stations (local scale)**

  Tamil Nadu Agriculture University (TNAU)

- **Satellite images**

- **Global agencies**

IPCC (Intergovernmental Panel on Climate Change)

NASA (National Aeronautics and Space Administration)

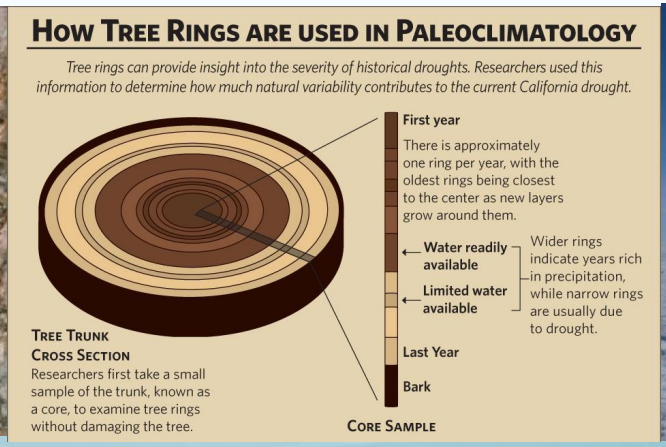
JMA (Japan Meteorological Agency)

IMD (India Meteorological Department)

Historical climate data

Climatologists collect historical temperature data using different methods:

- Tree rings
- Changes in ice volume and sea level
- Fossil pollen analysis
- Glacial movements



Historical climate data…

- One of the most fruitful approaches to record global temperatures involves an observed correlation between the world's ice cover and concentration of the isotope O^{18} in seafloor sediments.
- When water evaporates from the oceans it contains a mix of two isotopes O^{16} and O^{18}.
- O^{18} being heavier, water vapor containing O^{18} condenses and falls as precipitation somewhat sooner than water vapor containing O^{16}.
- Thus Precipitation over ocean tends to be slightly richer in O^{18} than precipitation that must travel further to reach polar ice sheets.
- Precipitation that forms glaciers and ice sheets are relatively depleted of O^{18}.

Historical climate data

- As the world's ice increases, it selectively removes O^{16} from the H_2O cycle and concentrates the remaining O^{18} in the oceans.
- Due to this marine organisms that build their shells out of calcium carbonate in seawater will have higher ratio of O^{18} to O^{16} in their shells when it is cold and more of the world's water is locked up in the glaciers and ice.
- By dating marine sediments and observing the ratio of the two oxygen isotopes in their carbonates, a historic thermometer can be created.
- By careful analysis of the isotope ratios in the Vostok ice core (a 2083 m long ice core recovered by the Soviets at Vostok in East Antarctica) a continuous 160,000 year temperature record is obtained.

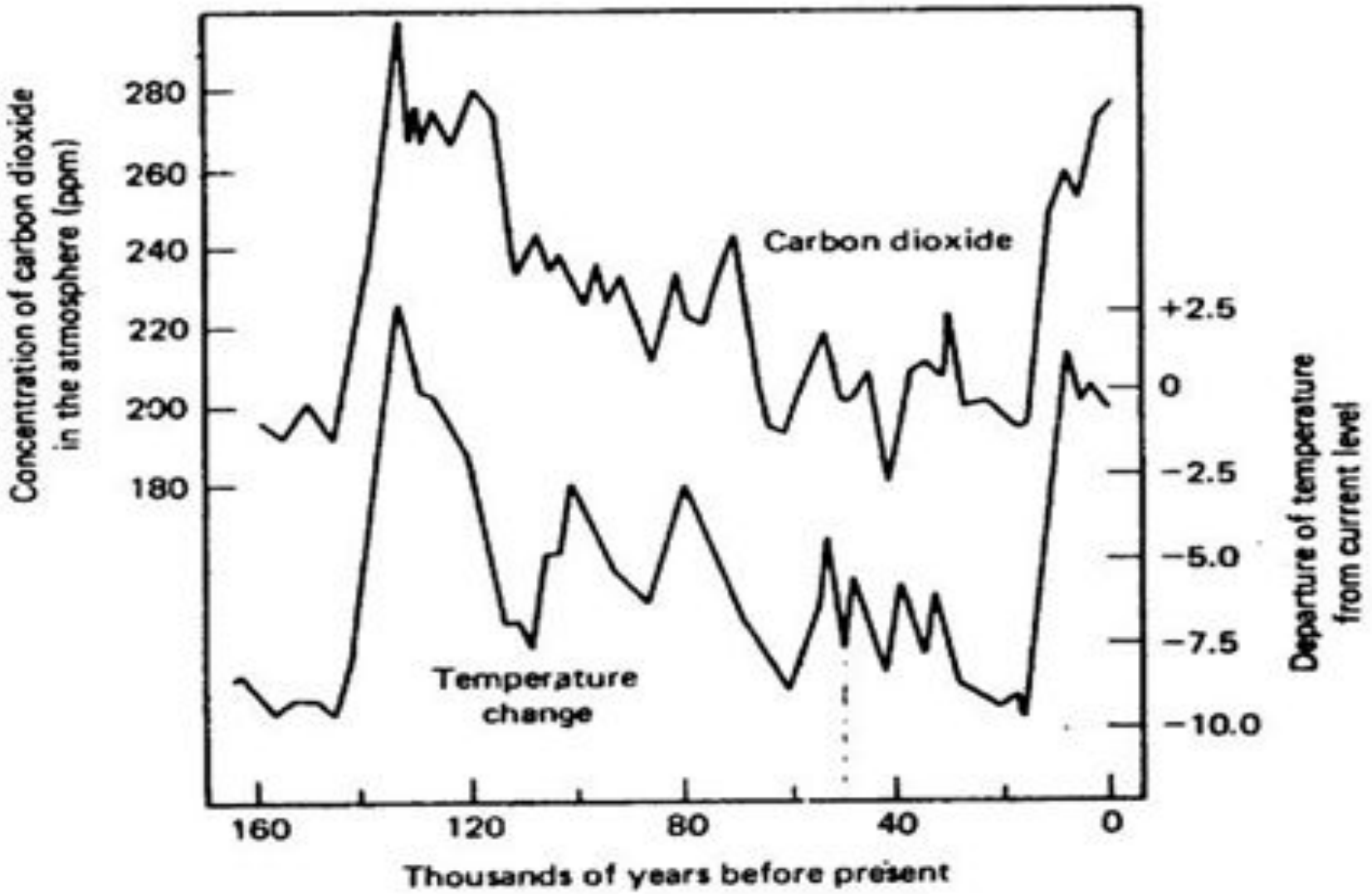
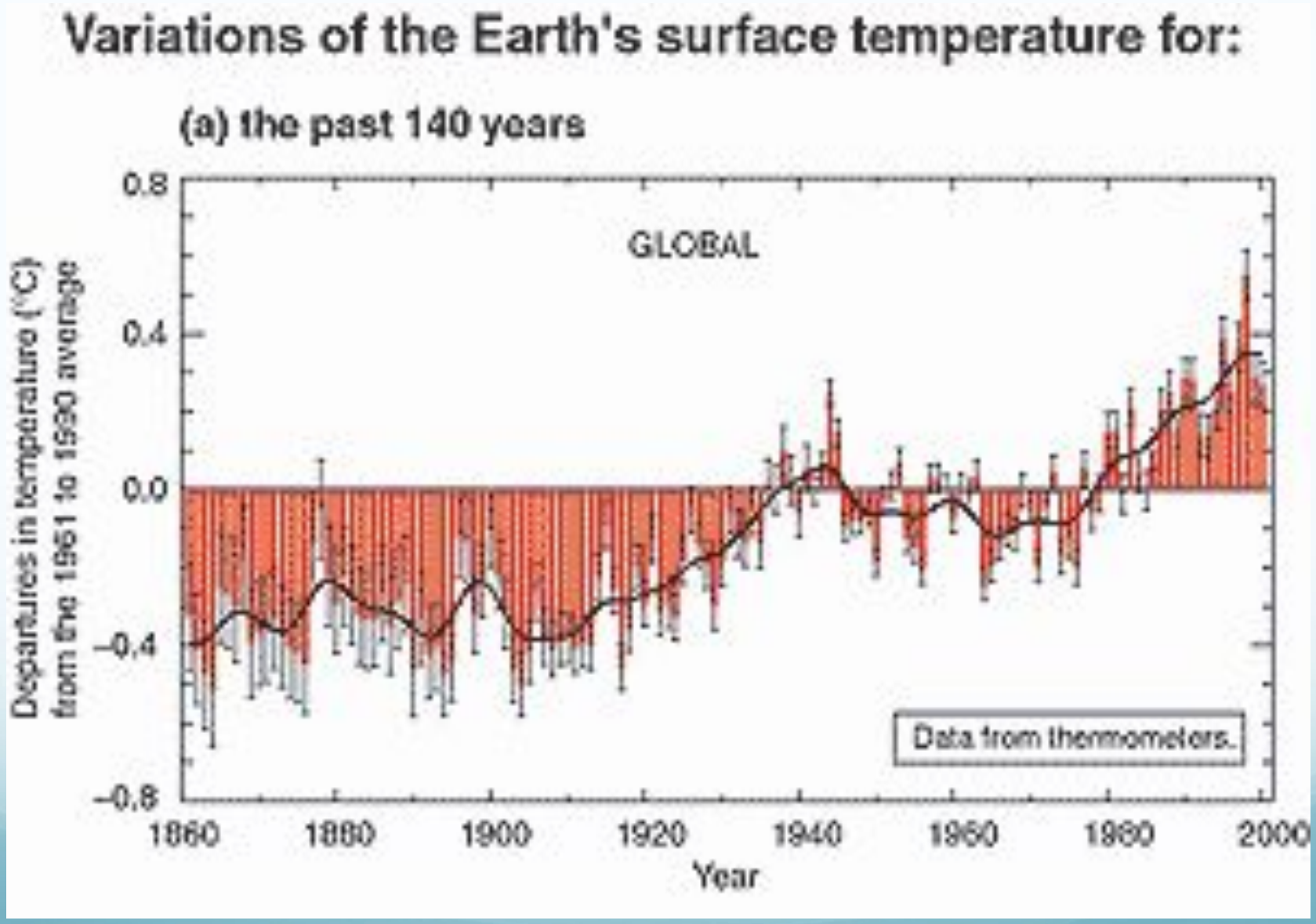


Figure 8.2 CO_2 concentrations (ppm) and Antarctic temperatures (°C) plotted against age in the Vostok record. Temperatures are referenced to current Vostok surface temperature. (*Source:* Barnola et al. Reprinted by permission from *Nature*, vol. 329. Copyright © 1987 Macmillan Magazines Ltd.)


Variations of the Earth's surface temperature for:
(a) the past 140 years
GLOBAL
Departures in temperature (°C) from the 1951 to 1980 average
0.8
0.4
0.0
-0.4
-0.8
1860
1880
1900
1920
1940
1960
1980
2000
Year
Data from thermometers.

Historical climate data..

- Historical record of global temperature shows a primary cycle between glacial episodes of about 100 000 years mixed with a periods of 23 000 years and 41 000 years
- The 100 000 years cycle is accounted with change in shape of earth's orbit from elliptical to circle
- 23 000 year cycle is associated with the precession or wobble of earth's spin axis
- 41 000 years cycle is related to earth's tilt.

Global Temperature Models

- Earth as a Black body
- This model predicts a global average temperature of 279 K (remarkably close to 288 K (15°C), actual global average temperature.
- Unfortunately this is a coincidence.

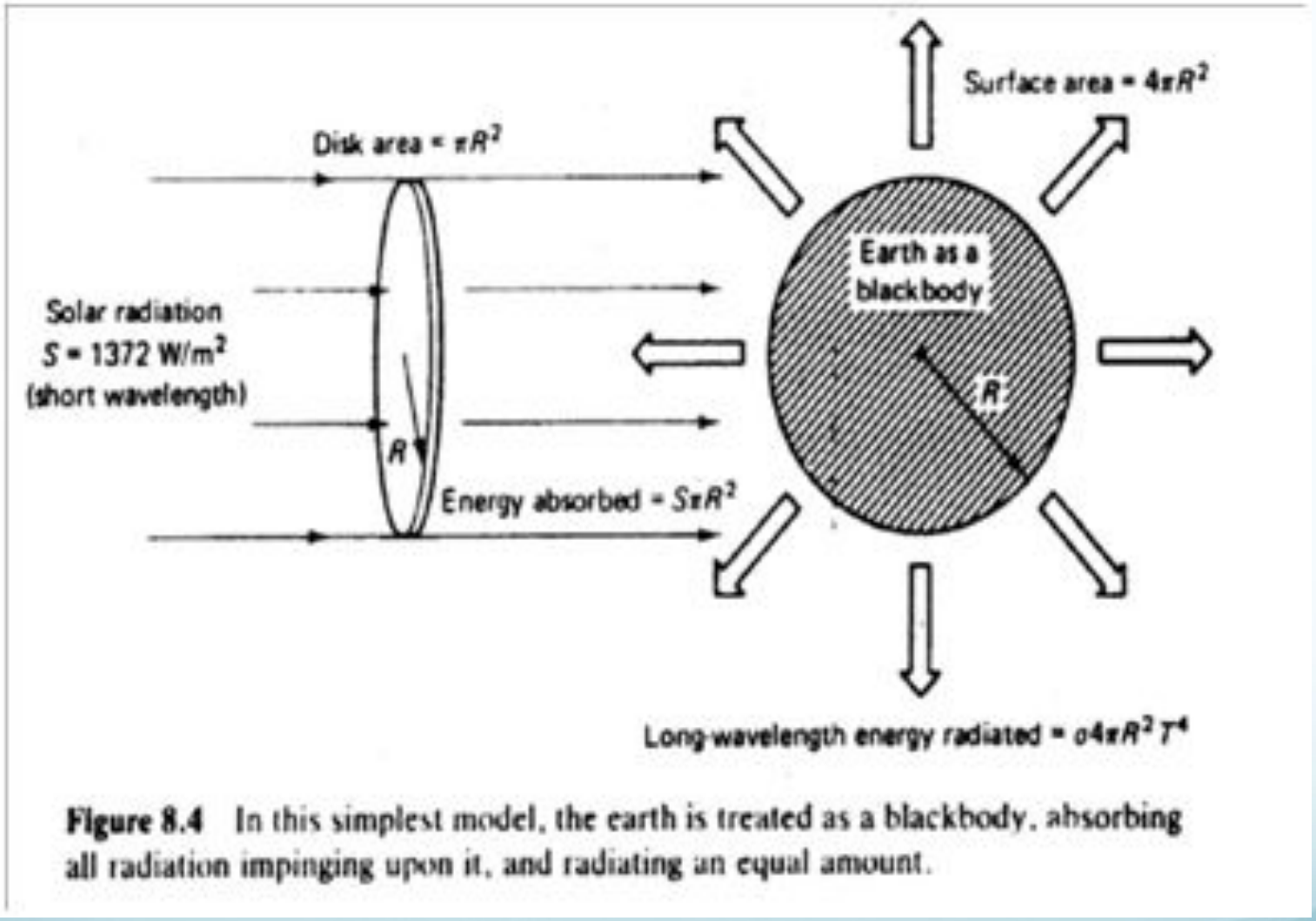


Figure 8.4 In this simplest model, the earth is treated as a blackbody, absorbing all radiation impinging upon it, and radiating an equal amount.

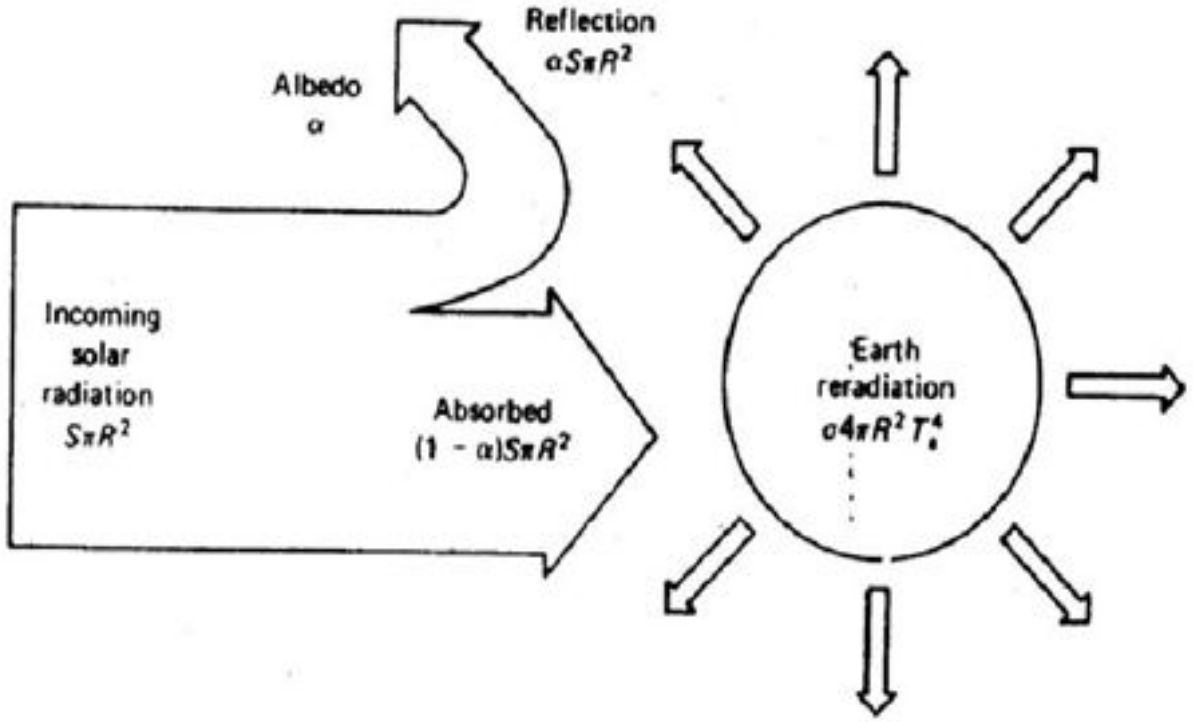


Figure 8.5 A more realistic model that includes the earth's albedo.

Simple radiation balance model that includes Earth's Albedo

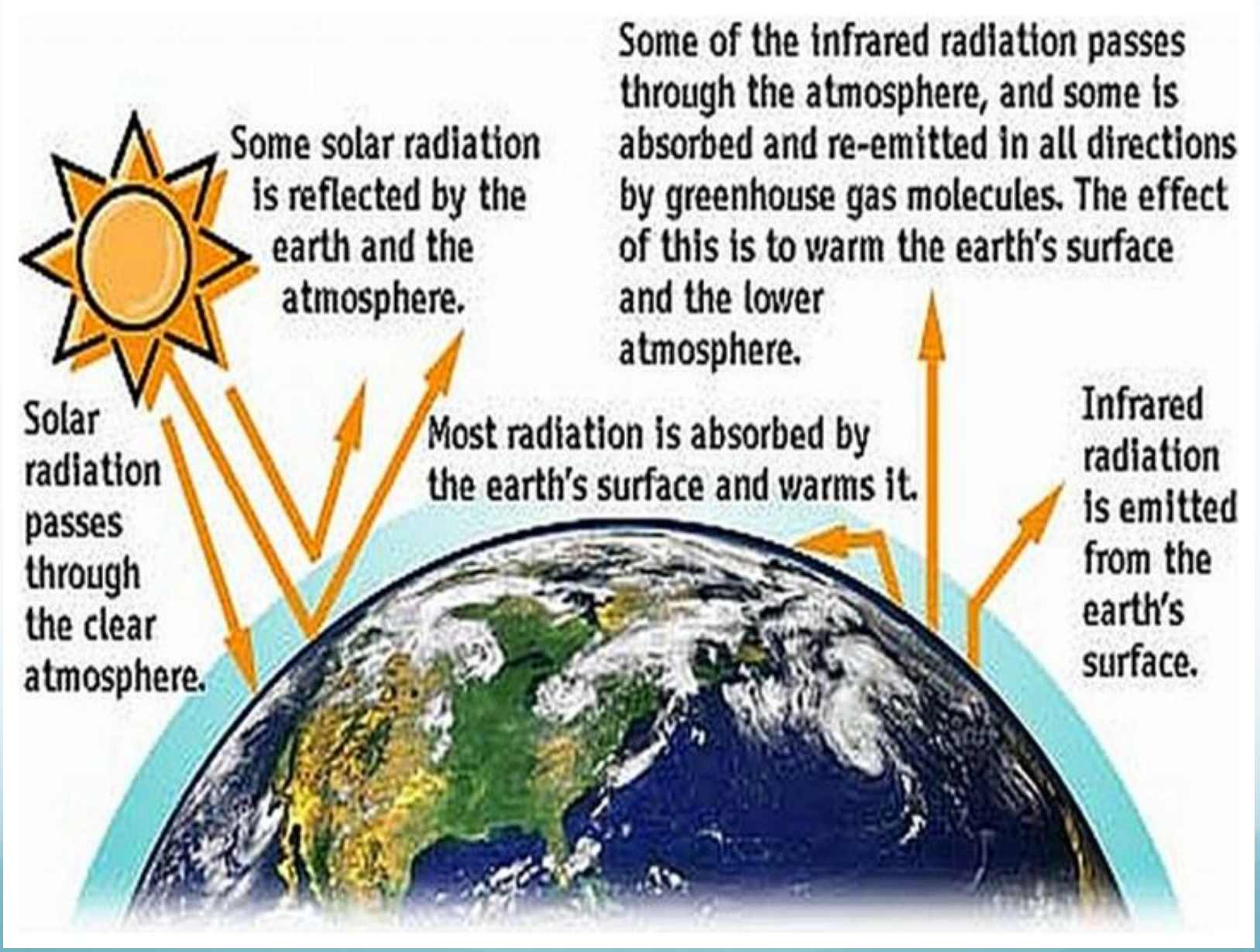
- The fraction of solar radiation that is reflected is known as *albedo (30 % for earth)*

- With this model the global average temperature is 255K! (it has worsened the situation)
  - What's Wrong?

The Green House Effect

- The surface of earth is 33°C higher than what is predicted.
- Solar energy is ***short wavelength*** *(less than 4 μm)*
- Energy radiated from Earth's surface is ***long wavelength*** *thermal radiation (more than 4 μm)*

Green House Effect



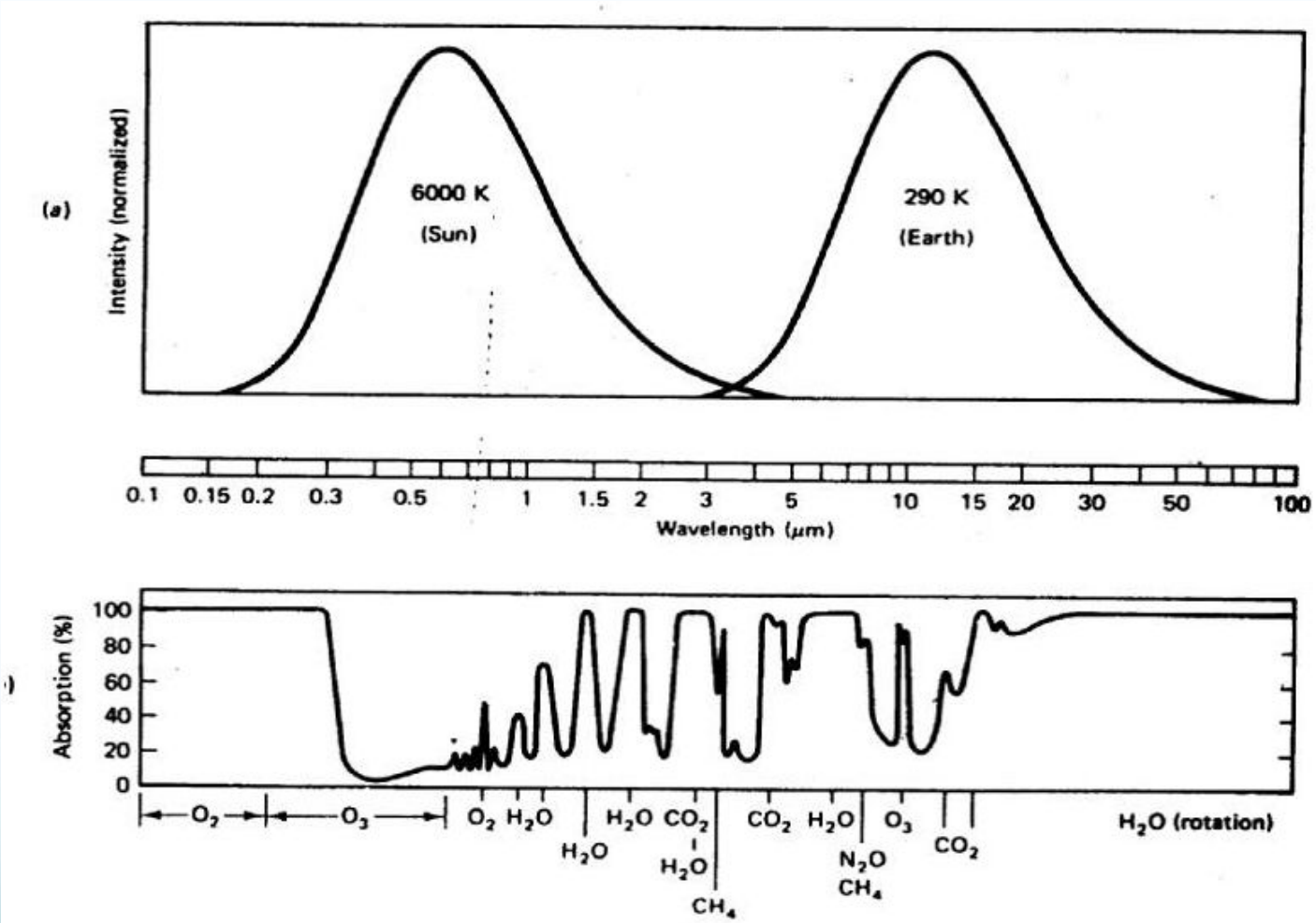
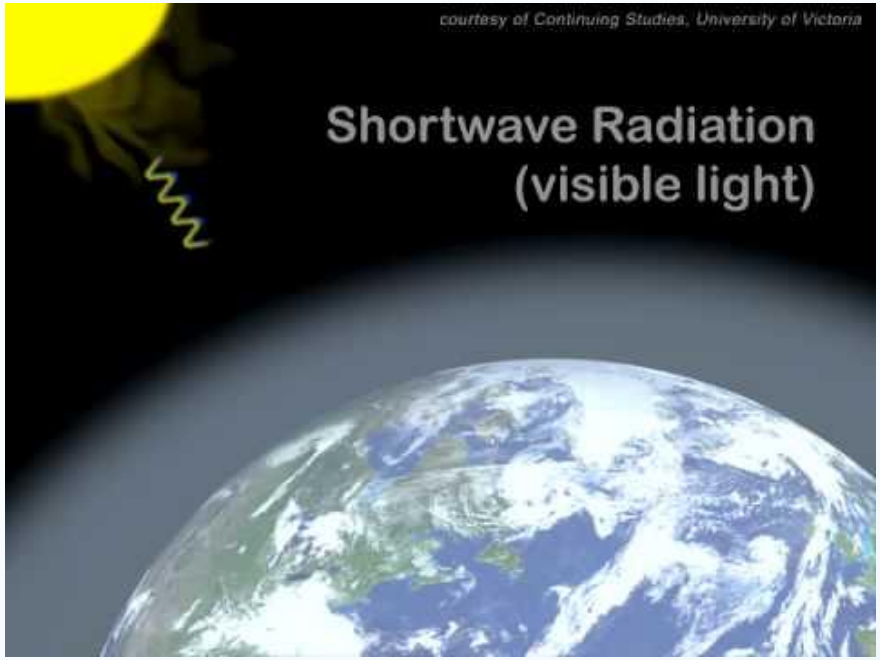


Figure 8.6 (*a*) Normalized blackbody radiation curves for the sun and earth. (*b*) Atmospheric absorption on a clear day. (Adapted from Wallace and Hobbs, 1977.)

The Green House Effect

- Most of the long wavelength radiations are absorbed by green house gases like water vapor, carbon dioxide, nitrous oxide and methane.
- These greenhouse gases act as a thermal blanket around the globe, raising the earth's temperature beyond the equivalent calculated temperature (this accounts for the 33°C)



Video: CO_2 and the Greenhouse Effect (8 min)

Greenhouse effect enhancement and consequences

- Anthropogenic sources of a number of gases are enhancing the green house effect resulting in Global Warming
- Calculations indicate that a rise in sea level of about ¼ m per degree Celsius.
- A total rise of 1-3 m is projected by the end of next century.

Carbon dioxide

- Global temperature is found to have close relation with presence of carbon dioxide in the atmosphere.
- 1 ppm of CO_2 = 2.12 giga ton CO_2
- At the beginning of 19^{th} century the concentration of carbon dioxide was around of 280 ppm.
- Present value of carbon dioxide is around 324 ppm.
- If an exponential growth is modeled, the carbon dioxide level will be 560 ppm by 2100!!

Worlds Changing Scenario

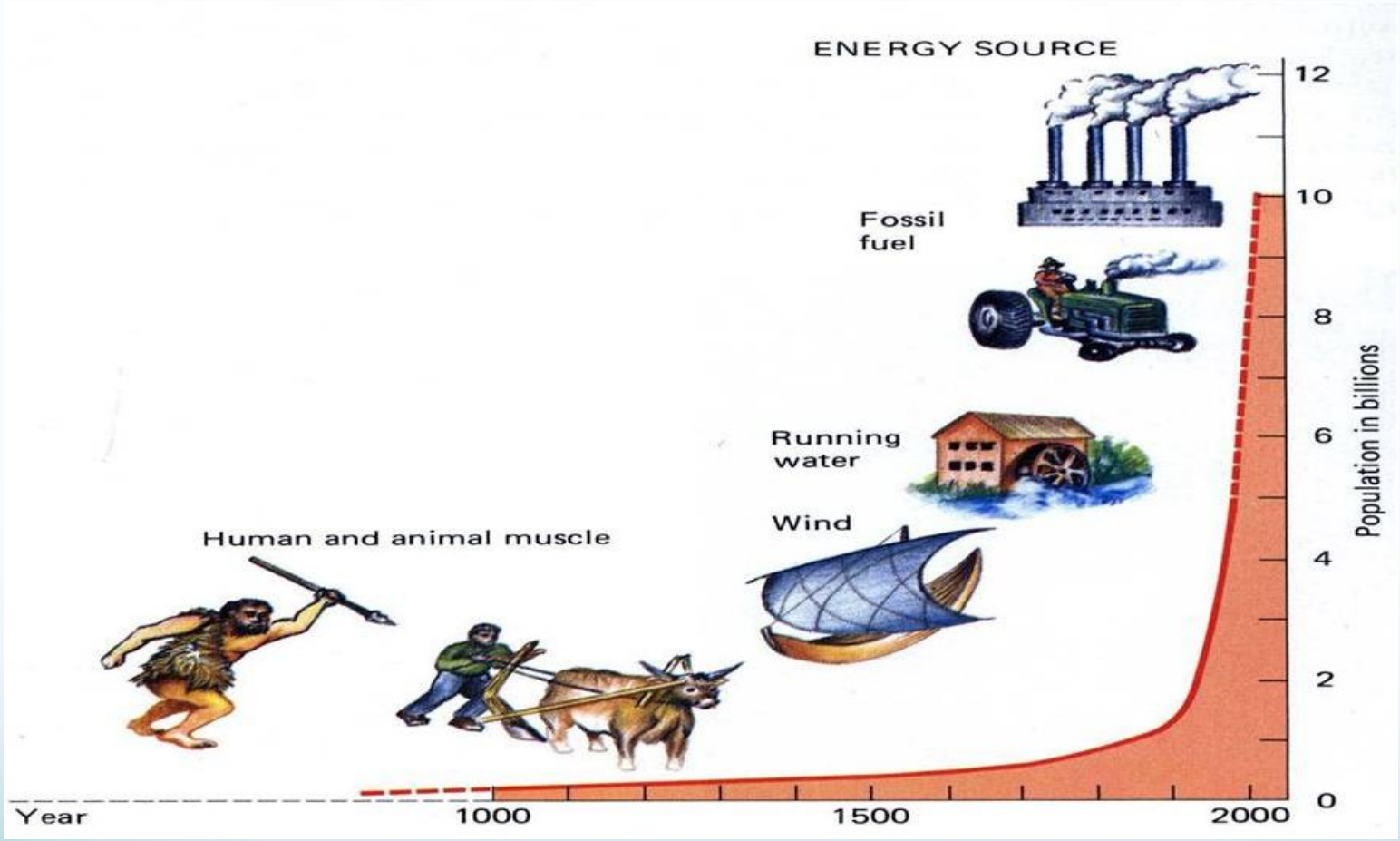


Table 8.3 summarizes some of the characteristics of these gases, including the relative greenhouse efficiency of each compared with carbon dioxide. A molecule of CFC, for example, exerts approximately 15 000 times the greenhouse warming effect as a molecule of CO_2. Table 8.3 also points out the relative global

TABLE 8.3 MAJOR GREENHOUSE GASES AND THEIR CHARACTERISTICS

Gas	Atmospheric concentration (ppm)	Annual concentration increase (%)	Relative greenhouse efficiency (CO_2 = 1)	Current greenhouse contribution (%)	Principal sources of gas
Carbon dioxide	351	0.4	1	57	Fossil fuels, deforestation
CFCs	0.00225	5	15 000	25	Foams, aerosols, refrigerants, solvents
Methane	1.675	1	25	12	Wetlands, rice, livestock, fossil fuels
Nitrous oxide	0.31	0.2	230	6	Fuels, fertilizer, deforestation

Source: Flavin (1989).

Are human activities modifying the atmosphere?

- The atmospheric concentration of carbon dioxide (CO_2) has increased by 31% since 1750 .
- "The atmospheric concentration of methane (CH_4) has increased by 151% since 1750 and continues to increase
- The atmospheric concentration of nitrous oxide (N_2O) has increased by 17% since 1750 and continues to increase.
- Snow cover and ice extent have decreased by about 10% when compared to 1960.

Chlorofluorocarbons

- These are molecules that contain chlorine, fluorine and carbon
- Their presence in the atmosphere is entirely due to human activities.
- These molecules are inert and non water soluble, so they are not destroyed through chemical reactions or removed with precipitation.

Global warming and Ozone –Depletion impacts of CFCs

- Fully halogenated CFCs have long atmospheric lifetimes,contain relatively large amounts of chlorine, and can absorb strongly within the 7 to 13 μm atmospheric window
- Therefore, they have considerable potential for global warming and ozone depletion.
- They are 15000 times potent than carbon dioxide

Other Greenhouse Gases

1. Methane

- Naturally occurring
- Increasing due to human activities
- Significant increase due to food-growing activities, cattle production
- It is also released during production, transportation and consumption of fossil fuels
- It absorbs at about 7.66 micrometer and 25 times as potent as carbon dioxide in global warming.

Other Greenhouse Gases

2. Ozone

- About 90% of Ozone resides in the stratosphere
- It protects us from UV radiations
- Increase in the Troposphere ozone can contribute to raising global temperature

Other Greenhouse Gases

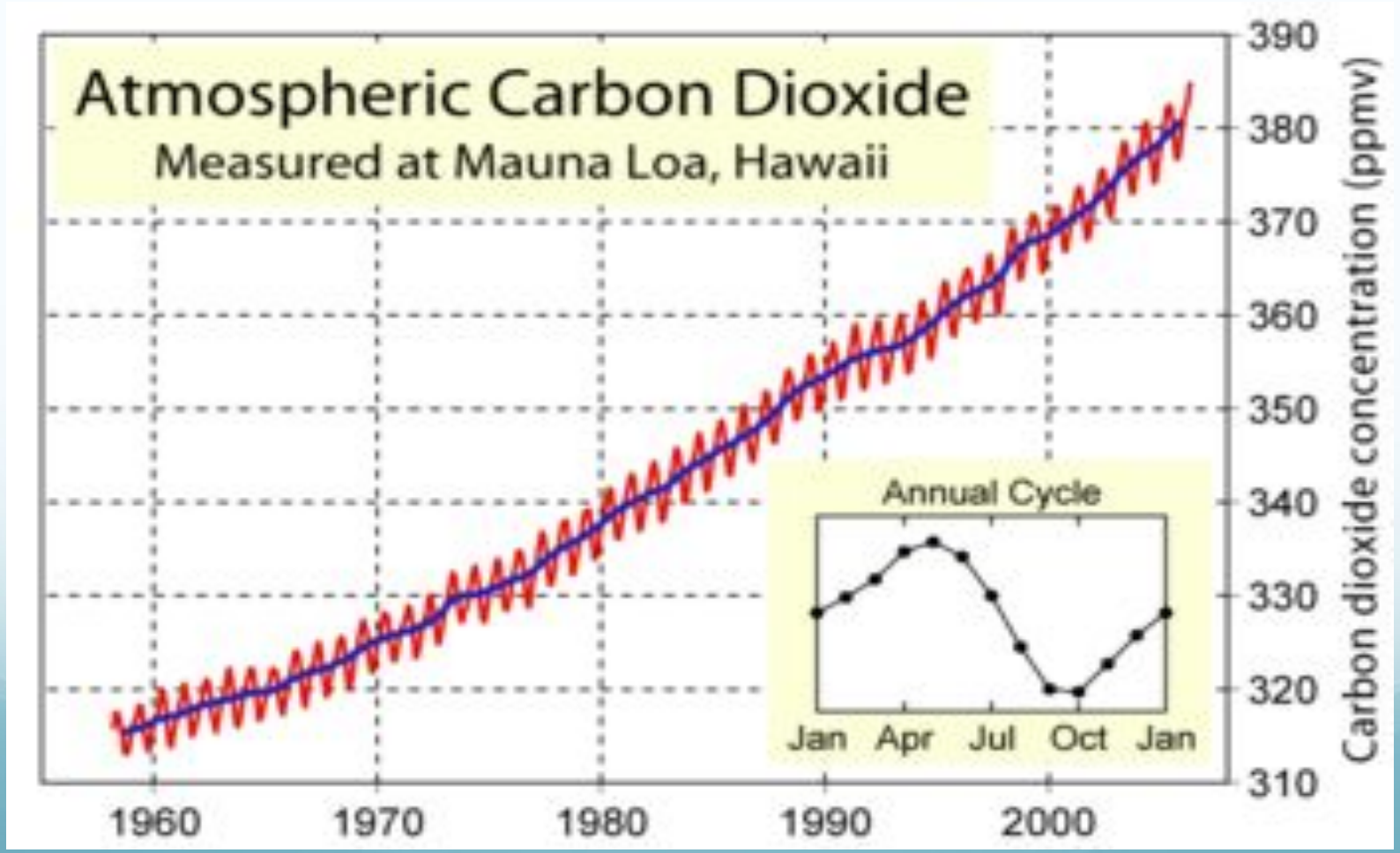
3. Nitrous Oxide

- Released into the atmosphere mostly during the nitrification portion of the nitrogen cycle.
- Combustion of fossil fuels and nitrogen fertilizer are the two major human activities that release this to the atmosphere
- It has strong absorption bands at 4,5,7,8 and 17 micrometer and it is about 280 times potent as carbon dioxide in causing global warming.

Global warming

- Increase in carbon dioxide emissions

The Keeling Graph



IPCC 2014 Reports:

"Warming of the climate system is unequivocal. It is extremely likely that human influence has been the dominant cause of observed warming since 1950".

"*…the longer we wait to reduce our emissions, the more expensive it will become*" .

GLOBAL WARMING

- Impact of high use of energy
- Worldwide repercussions
  - Natural hazards
  - Droughts and floods
  - Sea-level rise
  - Spread of infectious diseases

Is global warming occurring?


GREENLAND ICE SHEET MELT EXTENT
1992
2002

WORLD SCIENTISTS' WARNING TO HUMANITY (1992)

1670 distinguished scientists (including 104 Nobel Laureates) said:

"Human Beings and the natural world are on a collision course"

"We must move away from fossil fuels to cut greenhouse gas emissions"

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC)

- Set up in 1988 by World Meteorological Organization (WMO) to assess the science related to climate change
- Currently has 195 member countries
- IPCC provides scientific and intergovernmental based outlook to develop climate related policies

See also: http://www.ipcc.ch/

IPCC REPORT

Authors are eminent scientists from all over the globe grouped into 3 working group (WG)

WG-1: Physical Science Basis

WG-2:Impacts, Adaptation and Vulnerability, and

WG-3: Mitigation of Climate Change & the Task Force on National Greenhouse Gas Inventories (TFI)

United Nations Framework Convention on Climate Change

UNFCCC is one of the ramifications of the Rio Earth Summit 1992, started its function in 1994

Currently it is having 197 (countries) parties to the convention

The ultimate objective of UNFCCC:

"..stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system…"

Responses to Climate Change

As per UNFCCC, two fundamental response strategies to tackle Climate Change

Adaptation:

"refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities".

Mitigation:

"refers to implementing policies to reduce GHG emissions and enhance sinks and technological change and substitution that reduce resource inputs and emissions".

THE KYOTO PACT

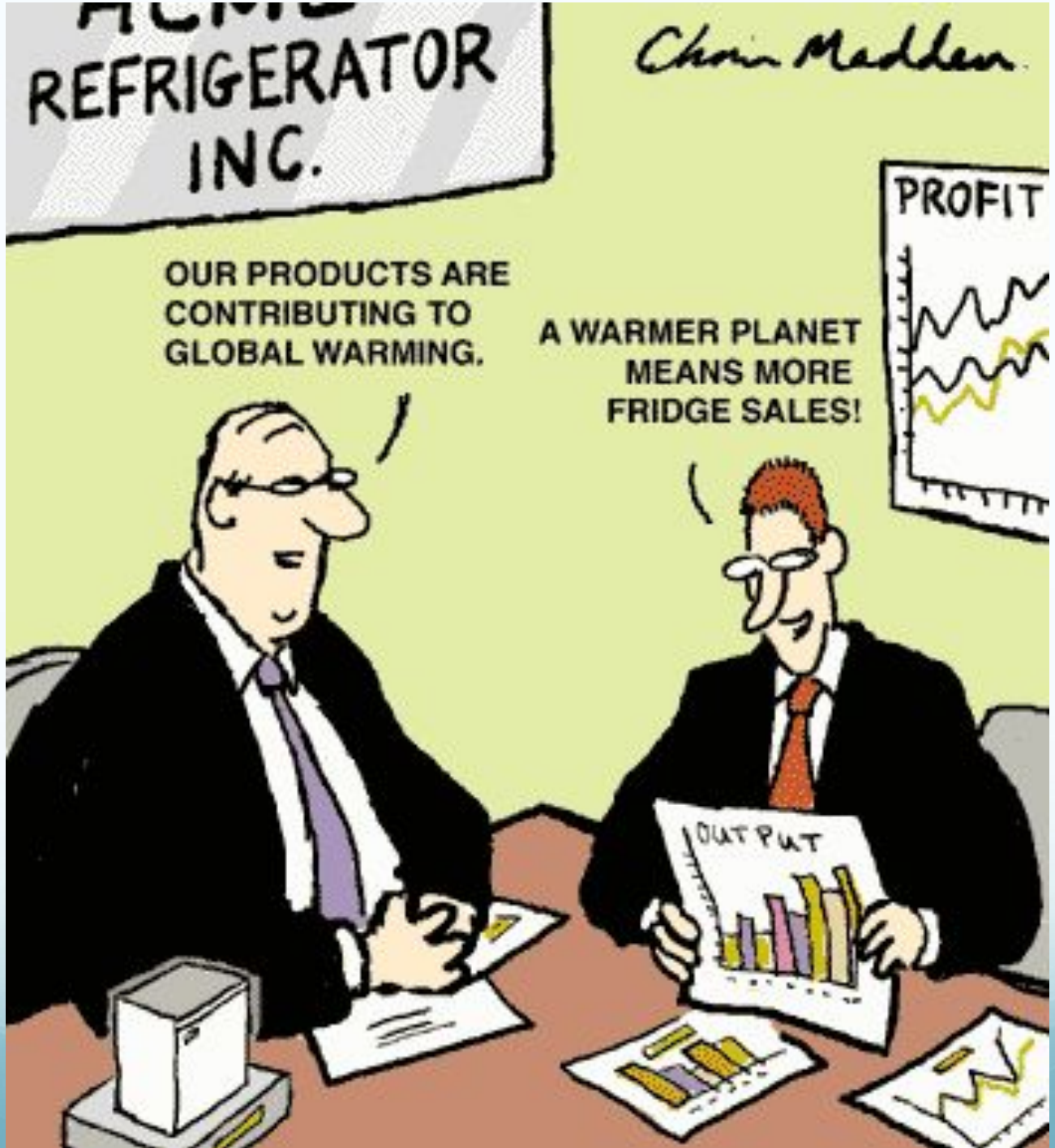
- Kyoto Pact is an UNFCCC agreement commits its Parties by CO_2 emission reduction targets
- Came into force on 16.2.2005
- First commitment period 2008-2012

  CO_2 emission reduction Target→5% in industrial nations 7% in US, below 1990 levels
- Second commitment period January 2013 to 31 December 2020

  Target: GHG emissions by at least 18% below 1990 levels

PARIS PACT

- UNFCC conference of parties (COP 21) held in Paris 2015
- Aim is to strengthen the global response to the threat of climate change
- Reaffirms the goal of keeping average warming below 2 degrees Celsius, also urging parties (highly vulnerable developing countries) to "pursue efforts" to limit it to 1.5 degrees
- "Prepare, communicate and maintain" a NDC (Nationally Determined Contributions) by parties


REFRIGERATOR INC.
Chris Madden
PROFIT
OUR PRODUCTS ARE CONTRIBUTING TO GLOBAL WARMING.
A WARMER PLANET MEANS MORE FRIDGE SALES!
OUTPUT

Impacts of Climate change and global warming

Climate change could kill up to 180 million people in Africa

150,000 people already die every year from climate change

Source: World Health Organisation

100 million more people will be flooded by end of century

30 million more people may be hungry because of climate change by 2050

Source: The Hadley Centre

Rising sea levels and crop failures could create 150 million refugees by 2100

Impacts of Climate change and global warming

Warmer land and waters and rising sea levels are detrimental to sensitive ecosystems

The rate of sea level rise over the Bay of Bengal is at the rate 0.75–6 mm/year (IITM, Pune 2016)

Many unique habitat in India under threat Eg: Sundarbans, world's largest mangrove forest, that abode Bengal tigers and many faunal sps.

Impacts of Climate change and global warming

Mass death of coral reefs because of coral bleaching widely reported in the recent past across the world is attributed to Global warming .

The research have noted that 1700 plants, animals and insects species moved pole wards at an average rate about 4 miles per decade in the last half of the 20th Century.

Over the past 25 years, penguin populations have shrunk by 33 percent in parts of Antarctica, due to declines in winter sea-ice habitat.

Impacts of Climate change and global warming

According to a new global study 90 percent of all large fishes have disappeared from the world's oceans in the past half century.

The golden toad (*Bufo periglenes*) of Costa Rica has disappeared as a direct result of global warming.

Oil from wells unable to meet demand, massive disruptions in transportation & economy, not enough time to switch to renewables

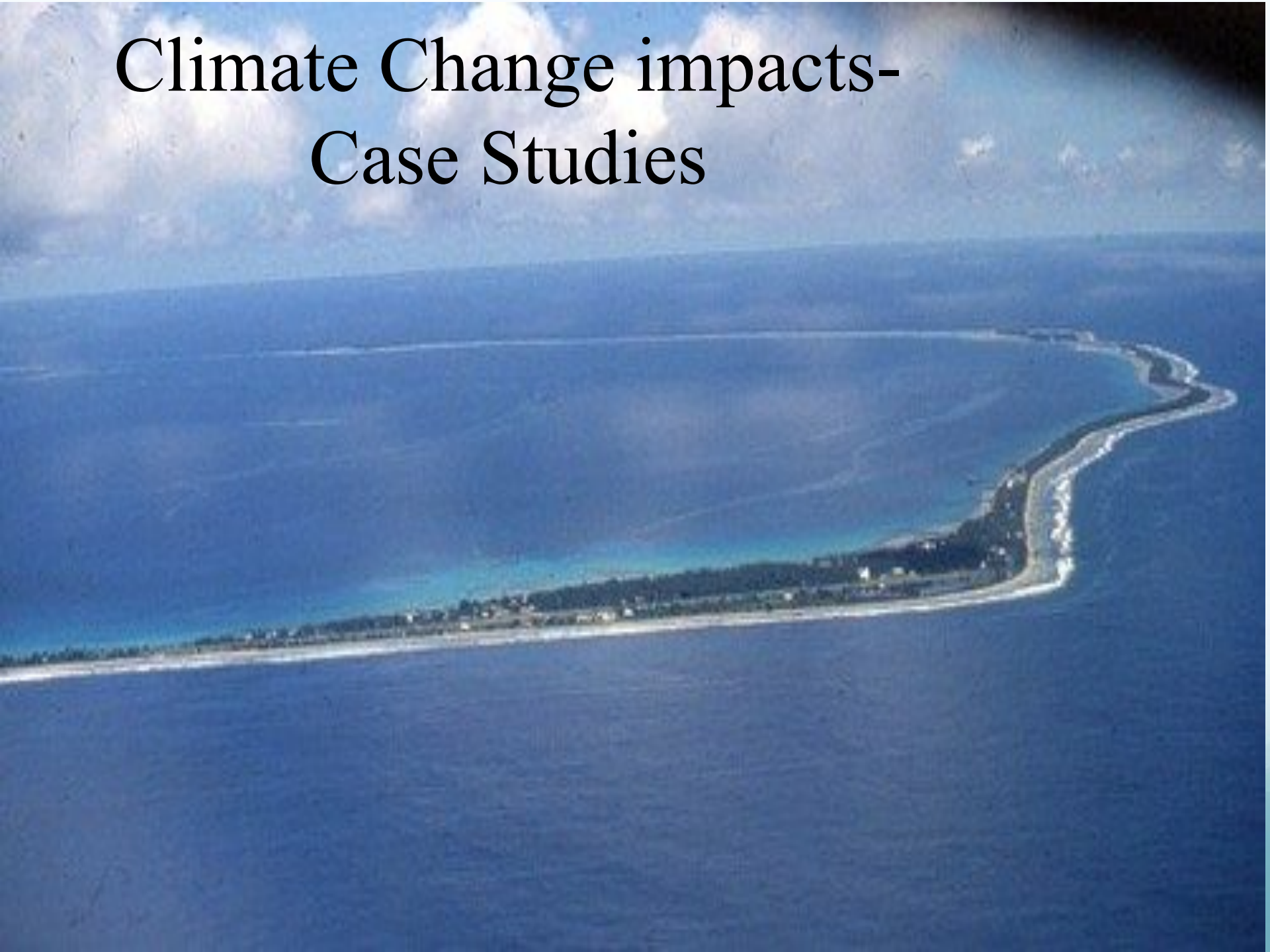
Climate Change and Global Warming - India

-Unpredictability in monsoon rains, which India's agriculture is heavily dependent on

-Temperature rise of between 2 and 3.5 degrees centigrade, would cost India a loss of between 9 and 25 percent of total agricultural revenue

-Melting glaciers will affect one-sixth of the world's population residing mainly in the Indian subcontinent.

Climate Change impacts- Case Studies



Tuvalu Islands

- Chain of nine coral islands in the South Pacific
- Small, remote islands between Hawaii and Australia.
- Area of 25 sq km and a population of 11,000
- Paradise with chalk-white beaches and coconut palms.

The problem:

- Islands located at low levels.
- Most houses are just three metres above sea level.

Tuvalu:
First victim of global warming?

- Sea level rise already a fact
- Salt water flowing up through porous fossil ground
- Traditional root crop, Pulaka, affected
- Tides are higher and the storms are more frequent and severe
- Crops and plantations are being destroyed by salt water
- People migrating to New Zealand,
- Tuvalu plans to file a case against industrialized countries in International Court of Justice.


Who doesn't want a house with a swimming pool? How about a house *IN* a swimming pool?

Tuvalu is far away.

We are still safe.

It will not happen everywhere.

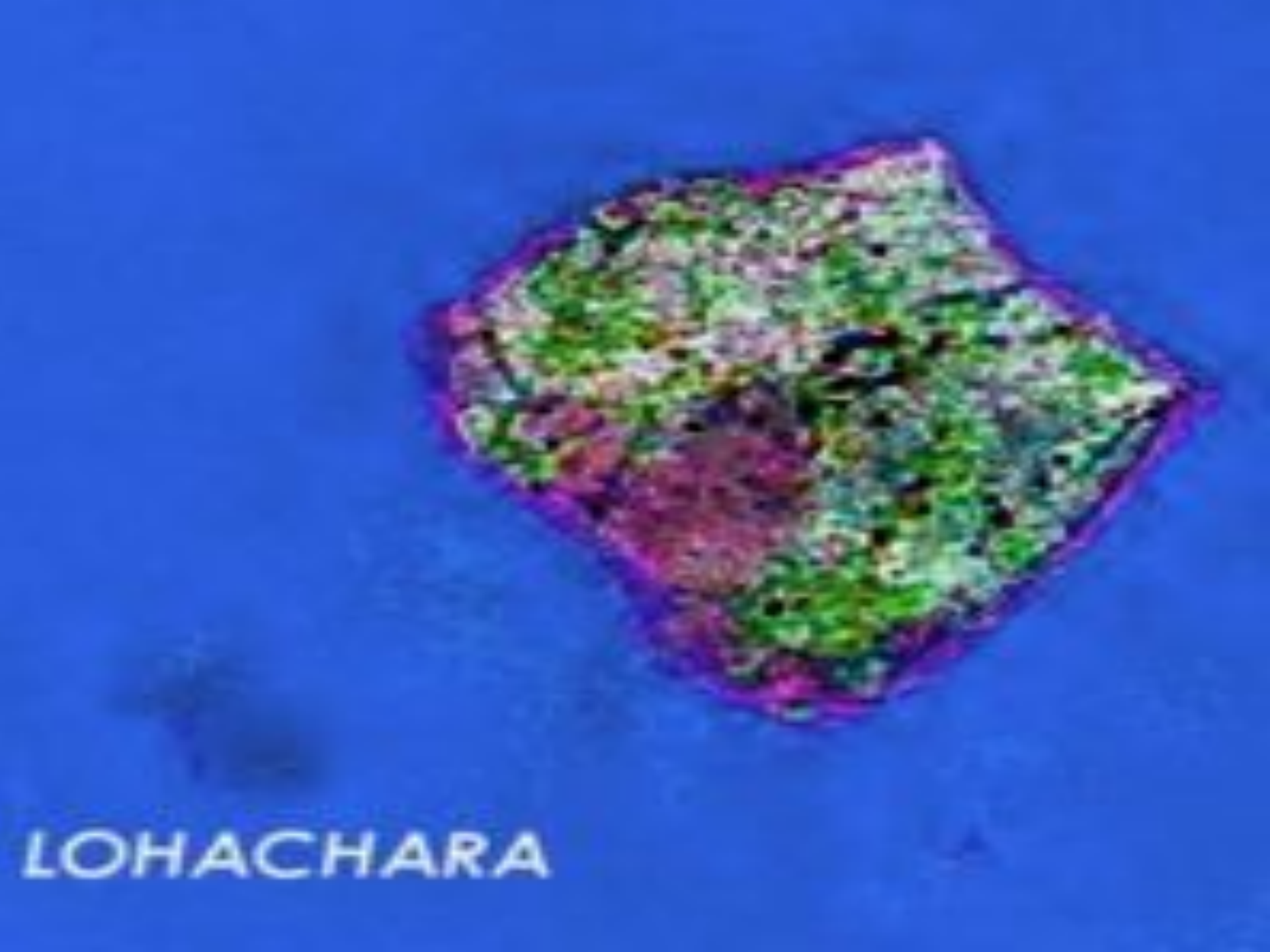
Is it true ?


Lohachara Char, India
Image © 2006 TerraMetrics
Google
elev 2 ft Streaming 100%
Eye alt 40057 ft

Sinking islands of the Sundarbans

- Coastal area of India and Bangladesh
- Island of Lohachara (10,000 people) has disappeared.
- Ghoramara: two-thirds gone
- 8 more islands likely to sink
  - 70,000 people have to move
  - 400 tigers in peril

Video: Sundarbans- Future Imperfect (10 min)


LOHACHARA