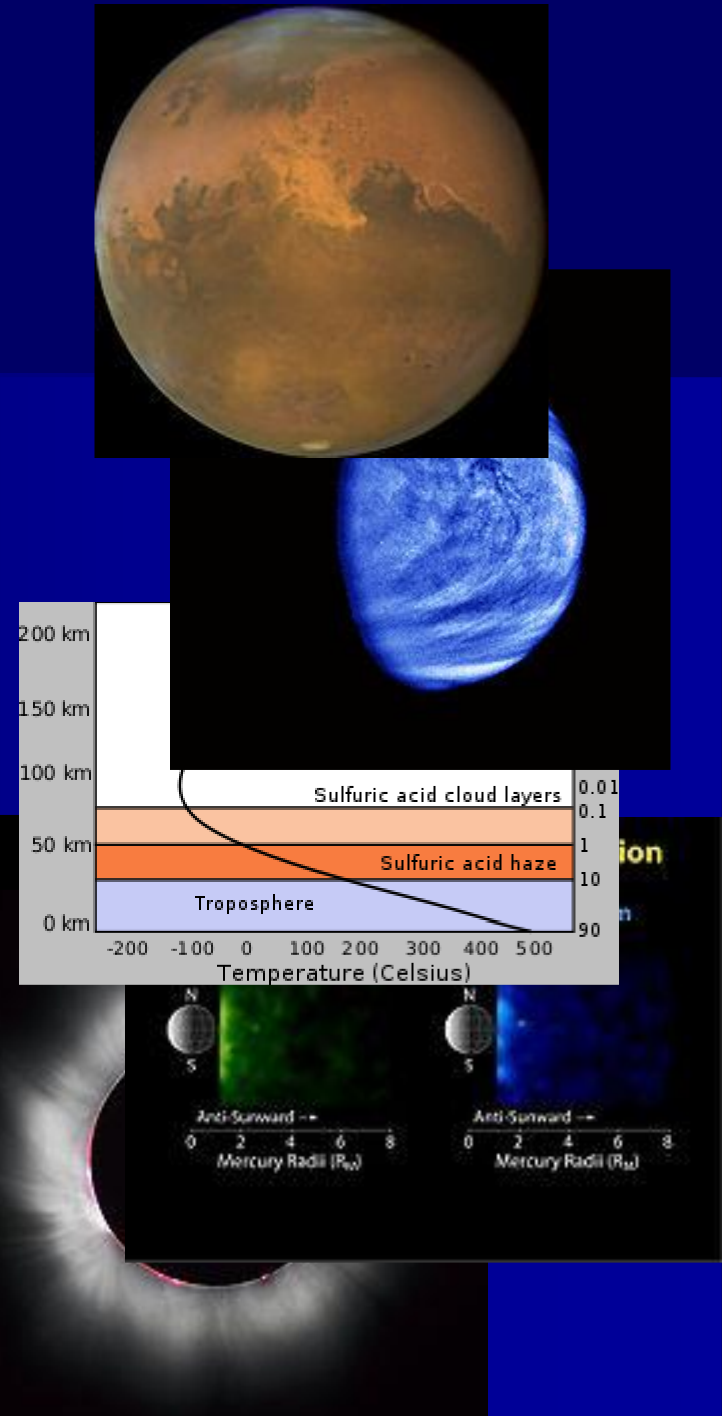
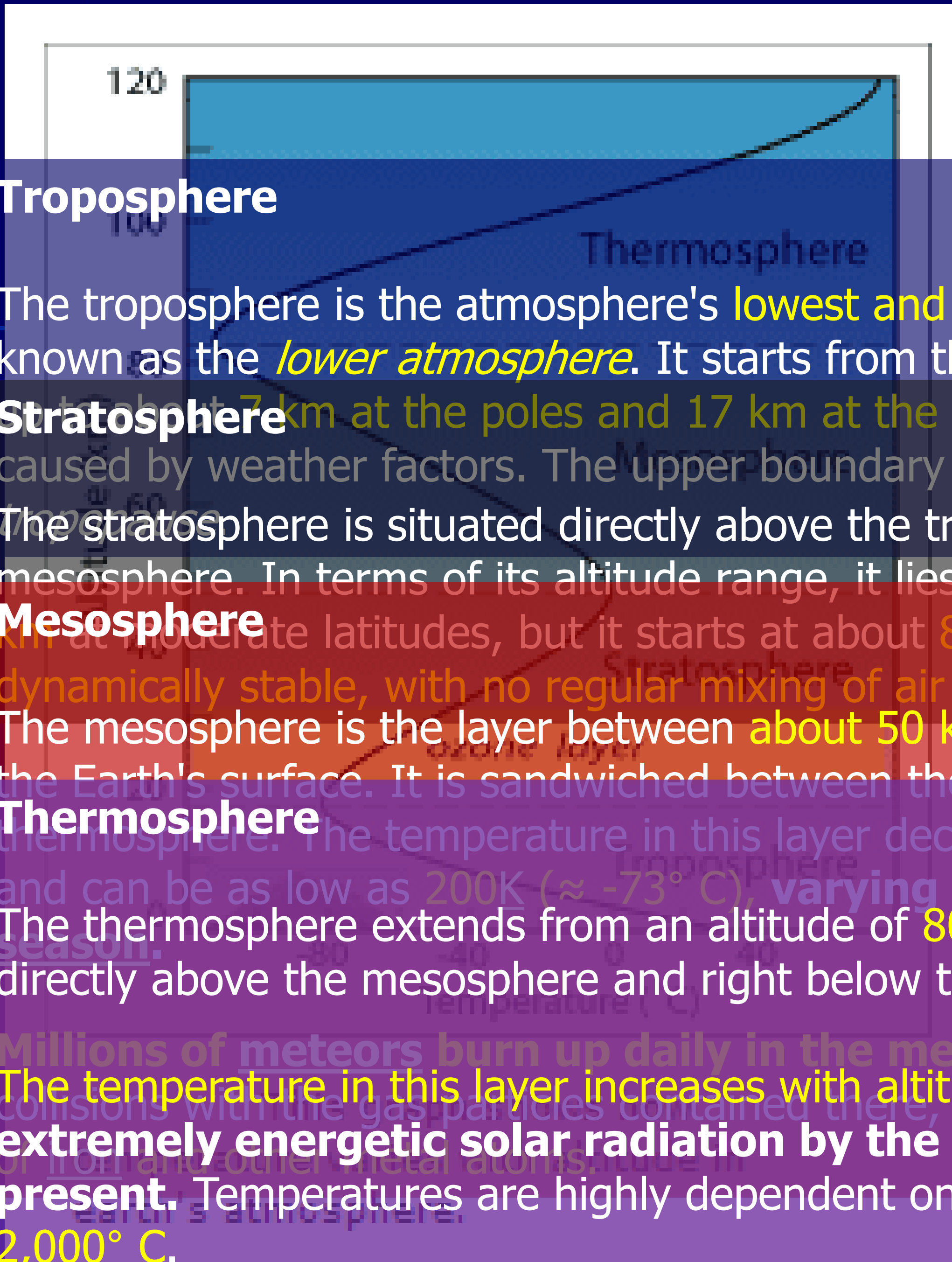
Space Physics

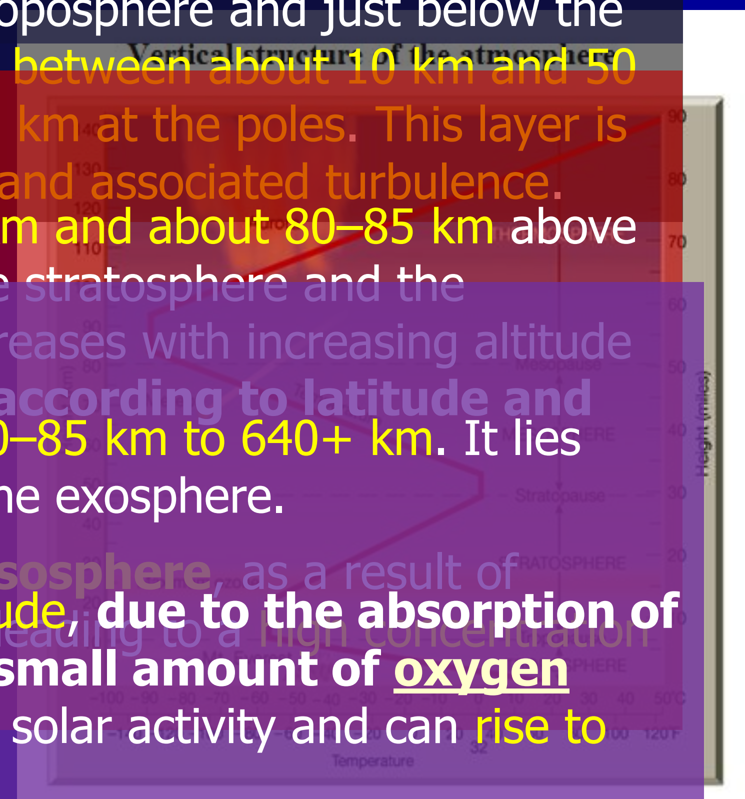
Space Physics



Lecture – 06

Temperature Profile





Troposphere

The troposphere is the atmosphere's lowest and densest layer, and it is also known as the *lower atmosphere*. It starts from the Earth's surface and reaches up to about 7 km at the poles and 17 km at the equator, with some variation caused by weather factors. The upper boundary of this layer is called the tropopause.

Stratosphere

The stratosphere is situated directly above the troposphere and just below the mesosphere. In terms of its altitude range, it lies between about 10 km and 50 km at moderate latitudes, but it starts at about 8 km at the poles. This layer is dynamically stable, with no regular mixing of air and associated turbulence.

Mesosphere

The mesosphere is the layer between about 50 km and about 80–85 km above the Earth's surface. It is sandwiched between the stratosphere and the thermosphere. The temperature in this layer decreases with increasing altitude and can be as low as 200K (≈ -73° C), **varying according to latitude and season.**

Millions of meteors burn up daily in the mesosphere, as a result of collisions with the gas particles contained there, leading to a high concentration of iron and other metal atoms.

Thermosphere

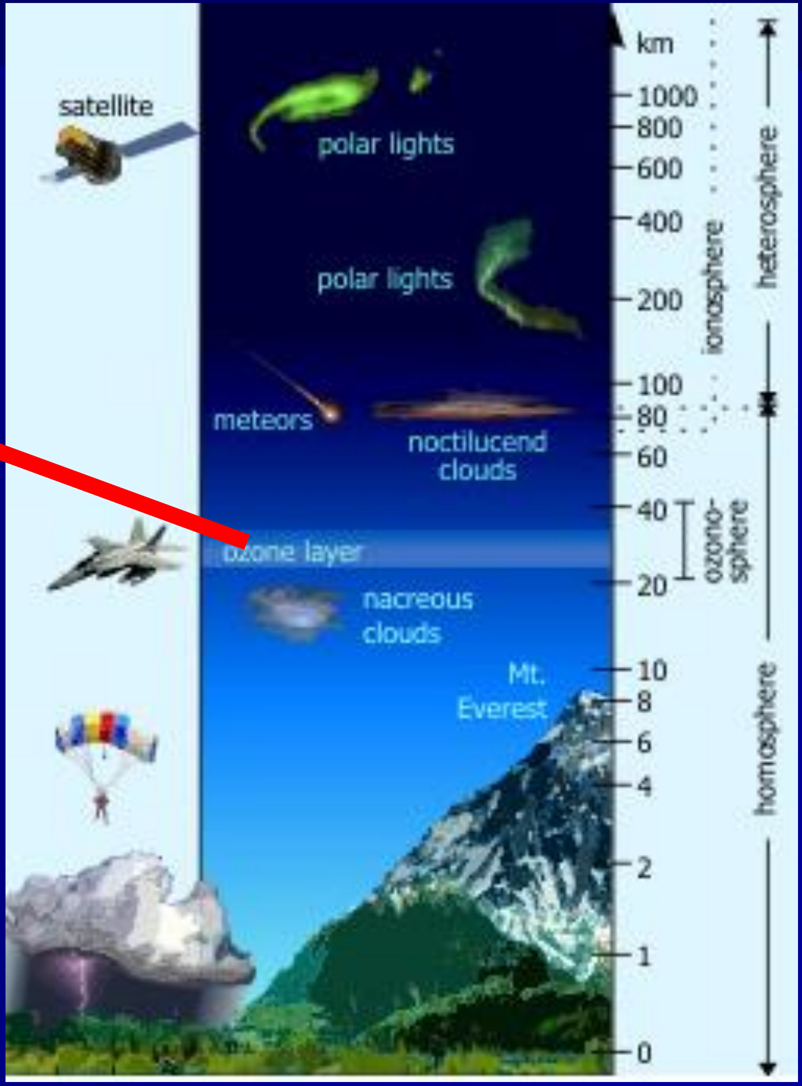
The thermosphere extends from an altitude of 80–85 km to 640+ km. It lies directly above the mesosphere and right below the exosphere.

The temperature in this layer increases with altitude, **due to the absorption of extremely energetic solar radiation by the small amount of oxygen present.** Temperatures are highly dependent on solar activity and can rise to 2,000° C.

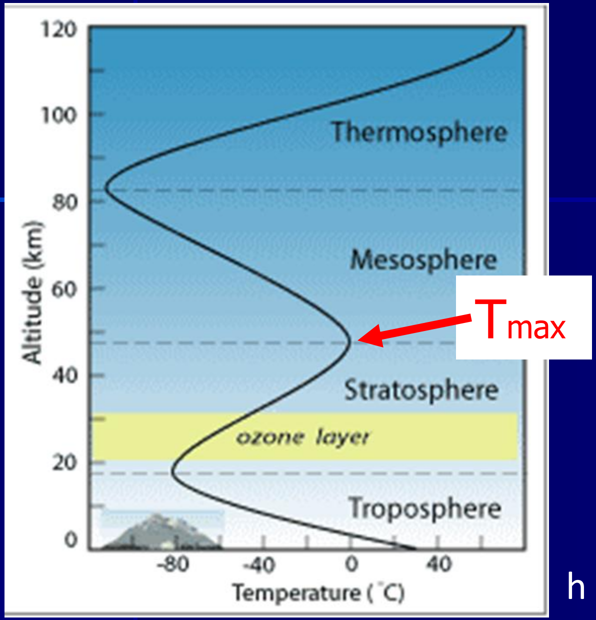
Atmosphere of Earth

Ozone layer (Ozonosphere):

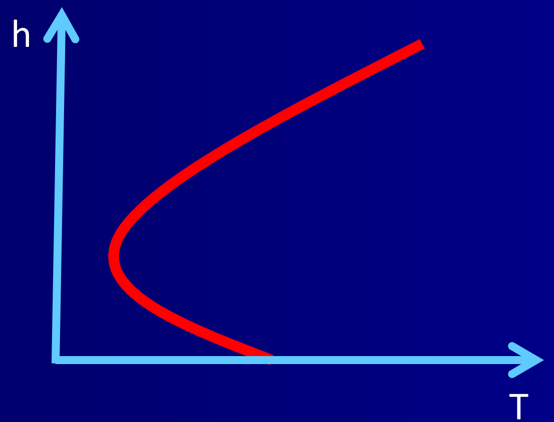
In the stratosphere, in an altitude range of about 10–50 km, the concentration of ozone (O3) is a few parts per million, which is much higher than the ozone concentration in the lower atmosphere **This layer, absorbs biologically harmful UV radiation from the Sun**.



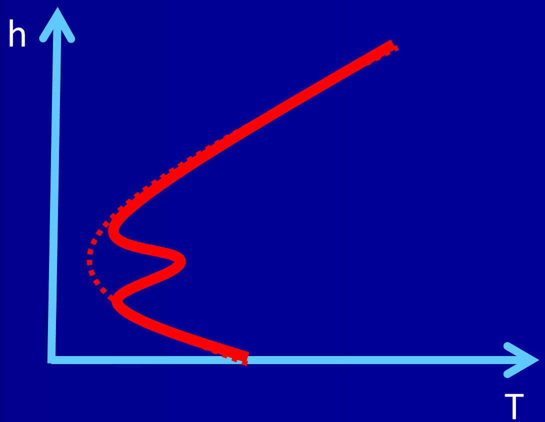
Ozone Layer :



This T_{max} of the middle of the graph, is **depend on the number of O_3 exist in the Ozone Layer**. If we study the graph of Height vs Temperature of any planet, we can get an idea whether it has an Ozone Layer or Not !



The Graph of h vs T of a planet which does not consist an Ozone Layer



The Graph of h vs T of a planet which consist an Ozone Layer

Origin of ozone

The photochemical mechanisms that give rise to the ozone layer were discovered by the British physicist **Sidney Chapman** in 1930.

Ozone in the Earth's stratosphere is created by ultraviolet light striking Oxygen molecules containing two oxygen atoms (O2), splitting them into individual oxygen atoms (atomic oxygen); the atomic oxygen then combines with unbroken O2 to create ozone, O3.

$$O_2 + E_{\text{From Sun}} \dashrightarrow O + O$$

$$O_2 + O \dashrightarrow O_3$$

Origin of ozone

The ozone molecule is also unstable (although, in the stratosphere, long-lived) and when ultraviolet light hits ozone it splits into a molecule of O_2 and an atom of atomic oxygen, a continuing process called the ozone oxygen cycle, thus creating an ozone layer in the stratosphere, the region from about 10 to 50 kilometres above Earth's surface.

$$O_3 + E_{UV} \longrightarrow O_2 + O + \text{Heat}$$

λ < 3100 Å

For this reaction, wave length of the UV radiation should be less than 3100 Å

Origin of ozone

About 90% of the ozone in our atmosphere is contained in the stratosphere. Ozone concentrations are greatest between about 20 and 40 kilometres, where they range from about 2 to 8 parts per million. If all of the ozone were compressed to the pressure of the air at sea level, it would be only a few mili-meters thick.

Origin of ozone

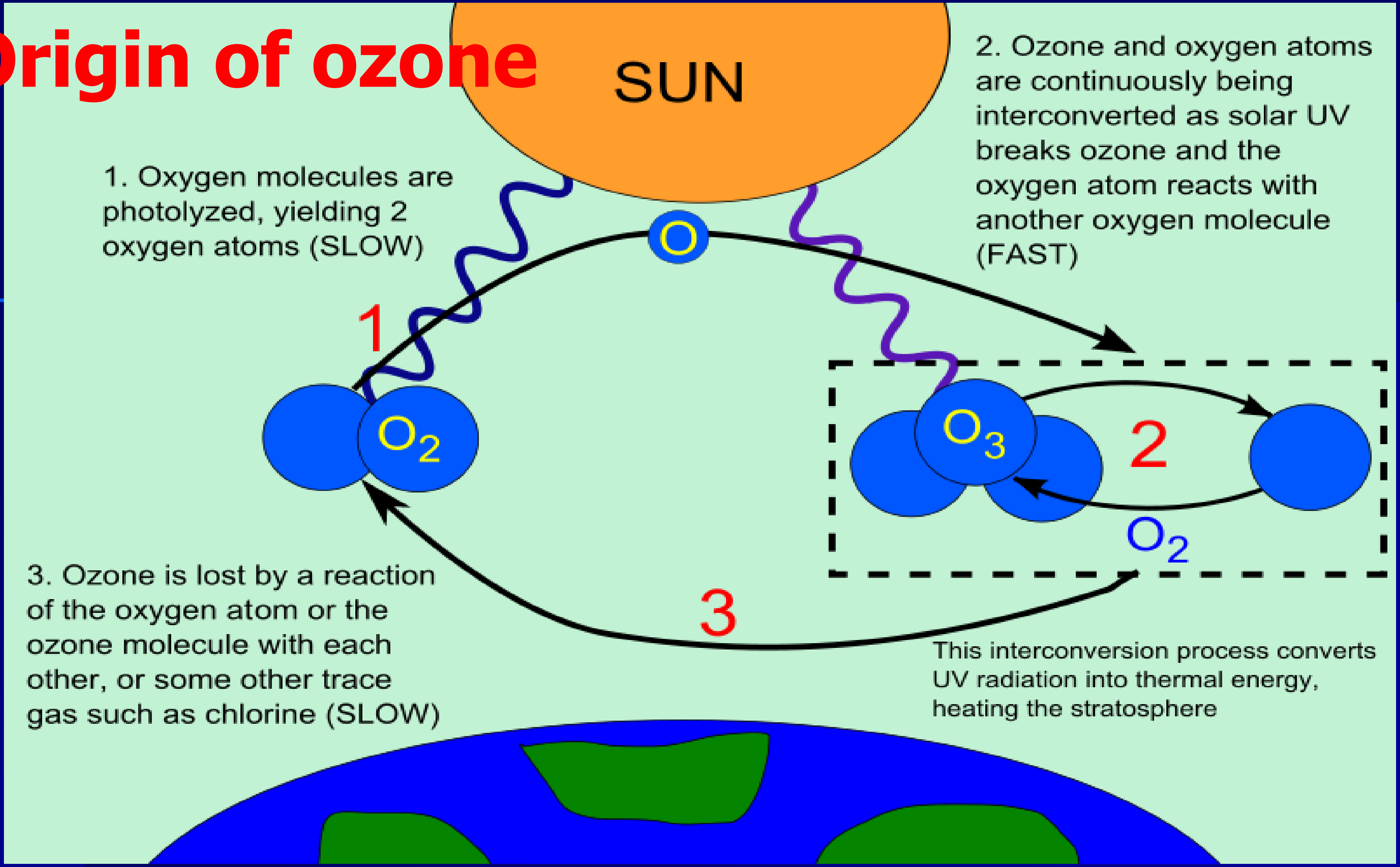
$$O_3 + E_{UV} \dashrightarrow O_2 + O + \text{Heat}$$

10^6 O_2 molecules are required to absorb the same amount of radiation that is absorbed by a single O_3 molecule. This is the importance of O_3!

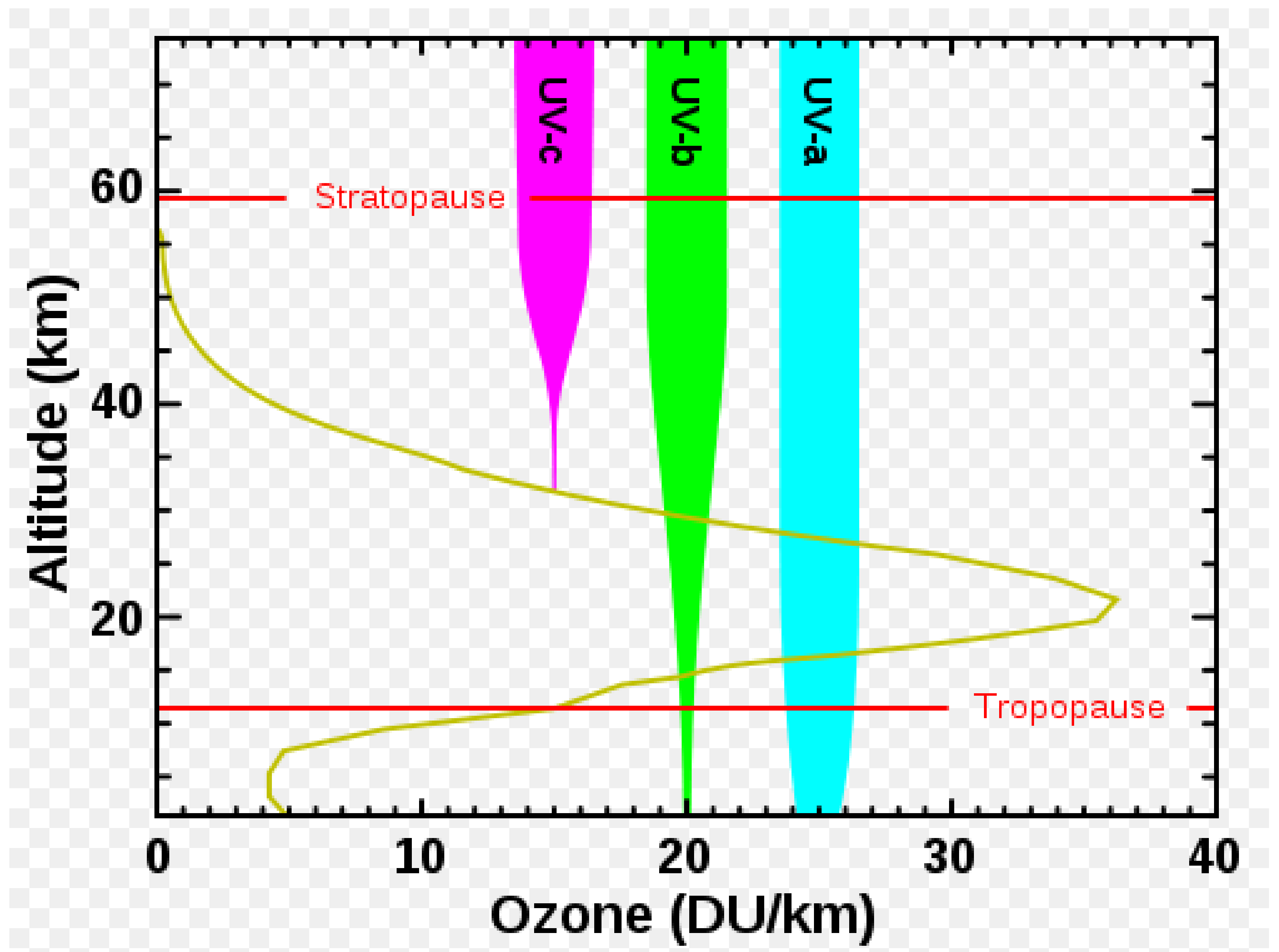
After O_3 reacting with UV radiation from the Sun, it produces O_2 and O irons and energy and again O_2 and O irons recombine naturally in the Ozone layer to reproduce O_3.

About 90% of the ozone in our atmosphere is contained in the stratosphere. Ozone concentrations are greatest between about 20 and 40 kilometres, where they range from about 2 to 8 parts per million. If all of the ozone were compressed to the pressure of the air at sea level, it would be only a few milimeters thick.

Origin of ozone

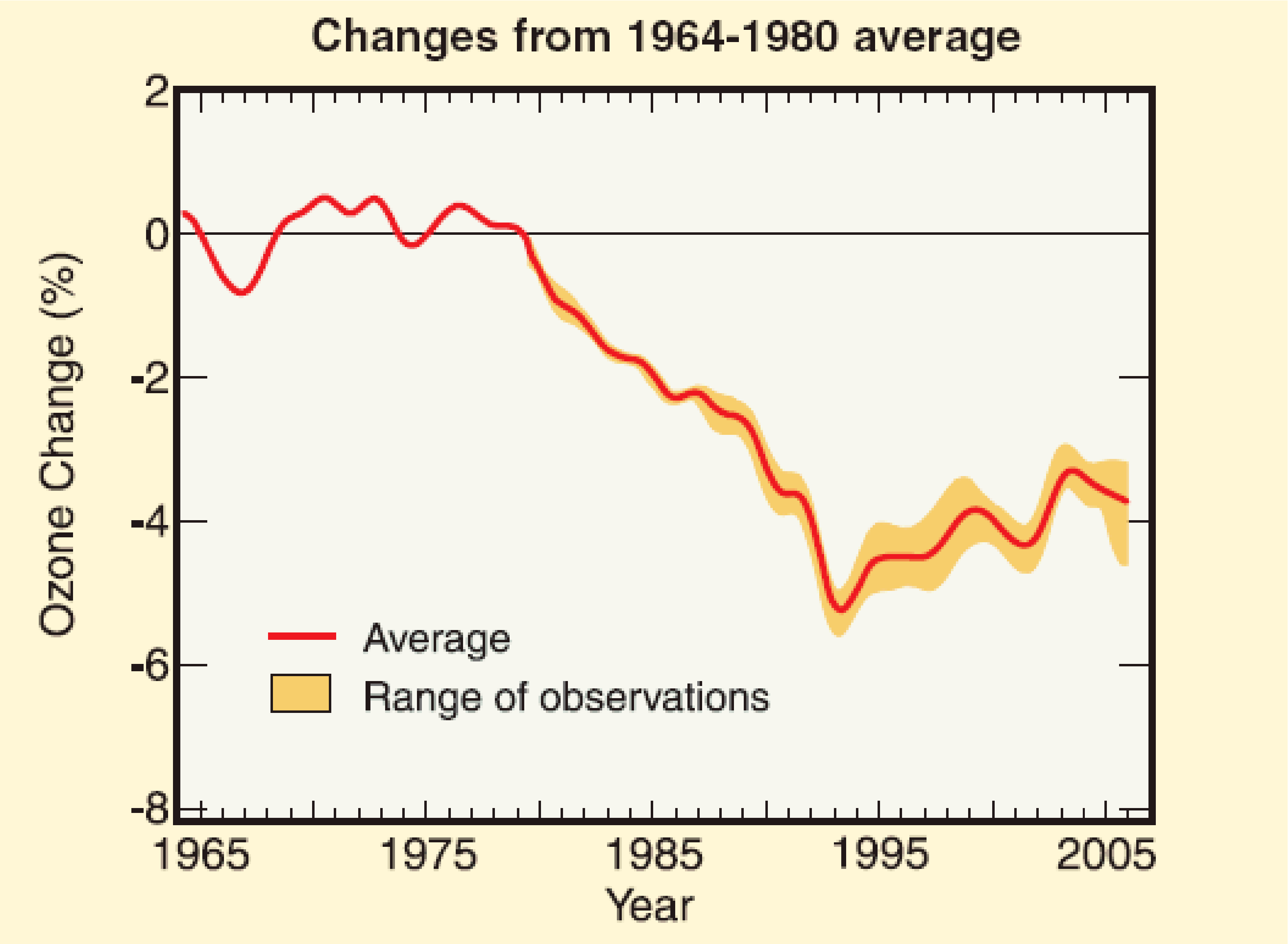


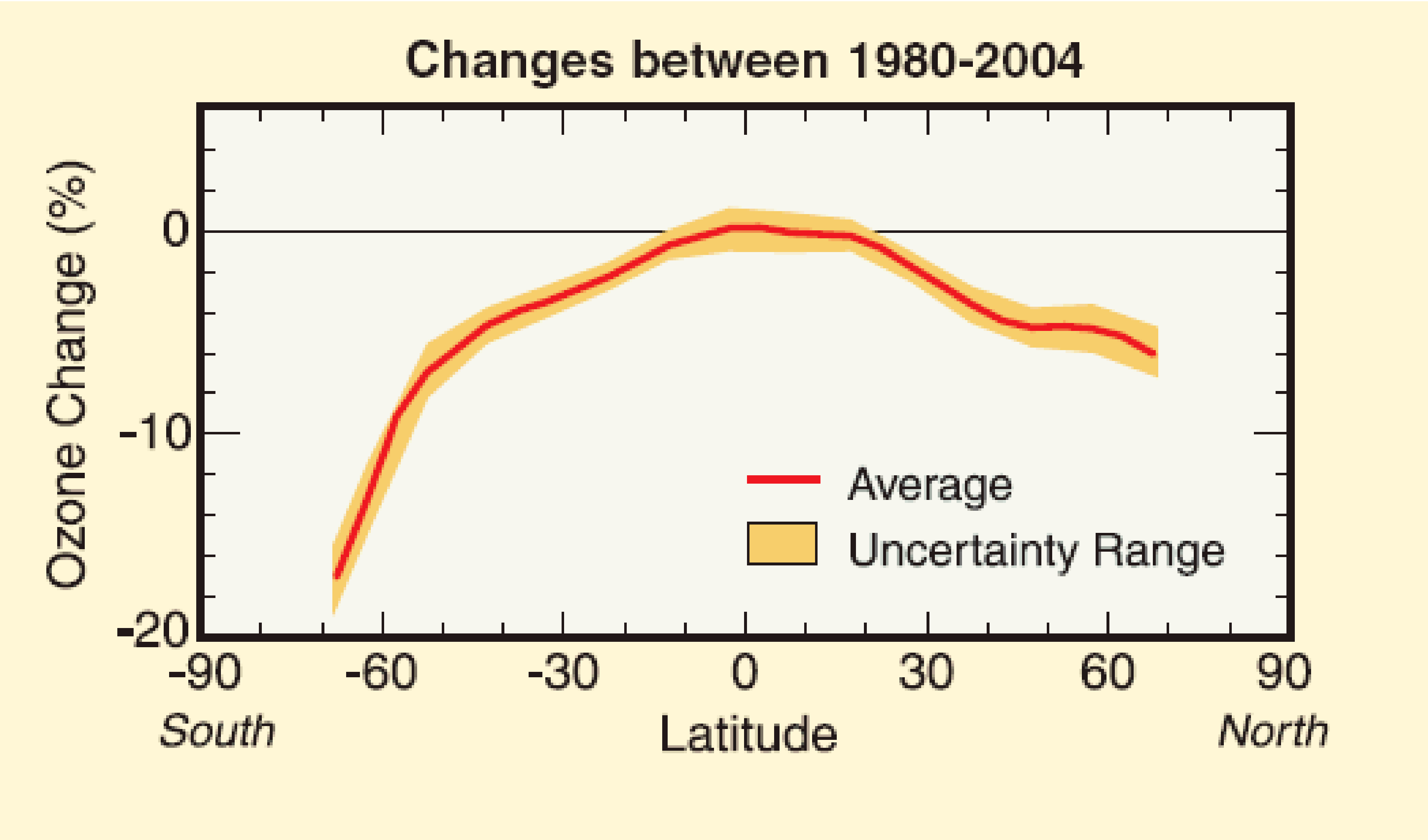
About 90% of the ozone in our atmosphere is contained in the stratosphere. Ozone concentrations are greatest between about 20 and 40 kilometres, where they range from about 2 to 8 parts per million. If all of the ozone were compressed to the pressure of the air at sea level, it would be only a few millimeters thick.



UV-c
UV-b
UV-a
Stratopause
Tropopause
60
40
20
Altitude (km)
0
10
20
30
40
Ozone (DU/km)

Global Total Ozone Change




Changes between 1980-2004
Ozone Change (%)
0
-10
-20
-90
-60
-30
0
30
60
90
South
Latitude
North
Average
Uncertainty Range

Ozone depletion

The ozone layer can be depleted by **free radical catalysts, including nitric oxide** (NO), **nitrous oxide** (N2O), **hydroxyl** (OH), **atomic chlorine** (Cl), and **atomic bromine** (Br).

While there are natural sources for all of these species, the concentrations of chlorine and bromine have increased markedly in recent years due to the release of large quantities of man-made **organohalogen compounds**, especially **chlorofluorocarbons** (CFCs) and **bromofluorocarbons**.

$$O3 \ + \ CFC \ \dashrightarrow \ O2 \ + \ O \ + \ CFC$$

Ozone depletion

$O3 + CFC \dashrightarrow O2 + O + CFC$

CFC (**chlorofluorocarbons**) molecules reacts with O_3 and it produces O_2 and O irons and again CFC. This released CFC again break O_3 and this process repeated continuously. As a result a small number of CFC molecules can break a large number of O_3 molecules to O_2 and O irons. The Cl in CFC molecules is the main cause to break O_3 molecules.

Because of this reason usage of an electrical items which contain CFC was prohibited !

Ozone depletion

O_3 + CFC ----→ O_2 + O + CFC

Because of this reason usage of an electrical items which contain CFC was prohibited !

5 PRODUCTS THAT CAUSE OZONE DEPLETION

1. Inhalers

2. Fire extinguisher

3. Aerosol hairsprays

4. Wasp (දෙබරා) and hornets (බඹරා) sprays

5. Foam insulation product

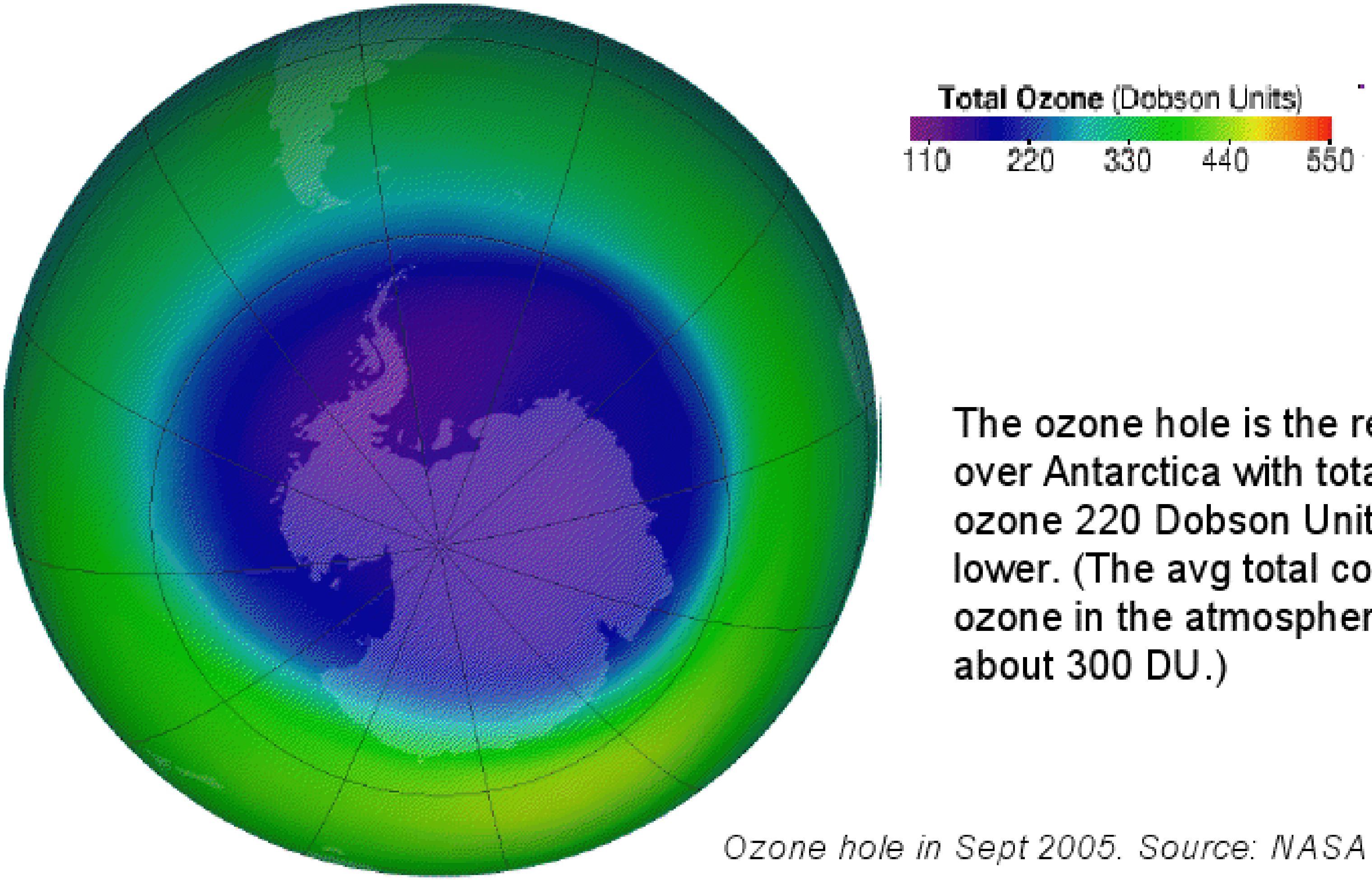
Ozone depletion

These highly stable compounds are capable of surviving the rise to the stratosphere, where Cl and Br radicals are liberated by the action of ultraviolet light. Each radical is then free to initiate and catalyze a chain reaction capable of breaking down over 100,000 ozone molecules. The breakdown of ozone in the stratosphere results in the ozone molecules being unable to absorb ultraviolet radiation. Consequently, unabsorbed and dangerous ultraviolet-B radiation is able to reach the Earth’s surface.

In 2009, nitrous oxide (N_2O) was the largest ozone-depleting substance emitted through human activities.

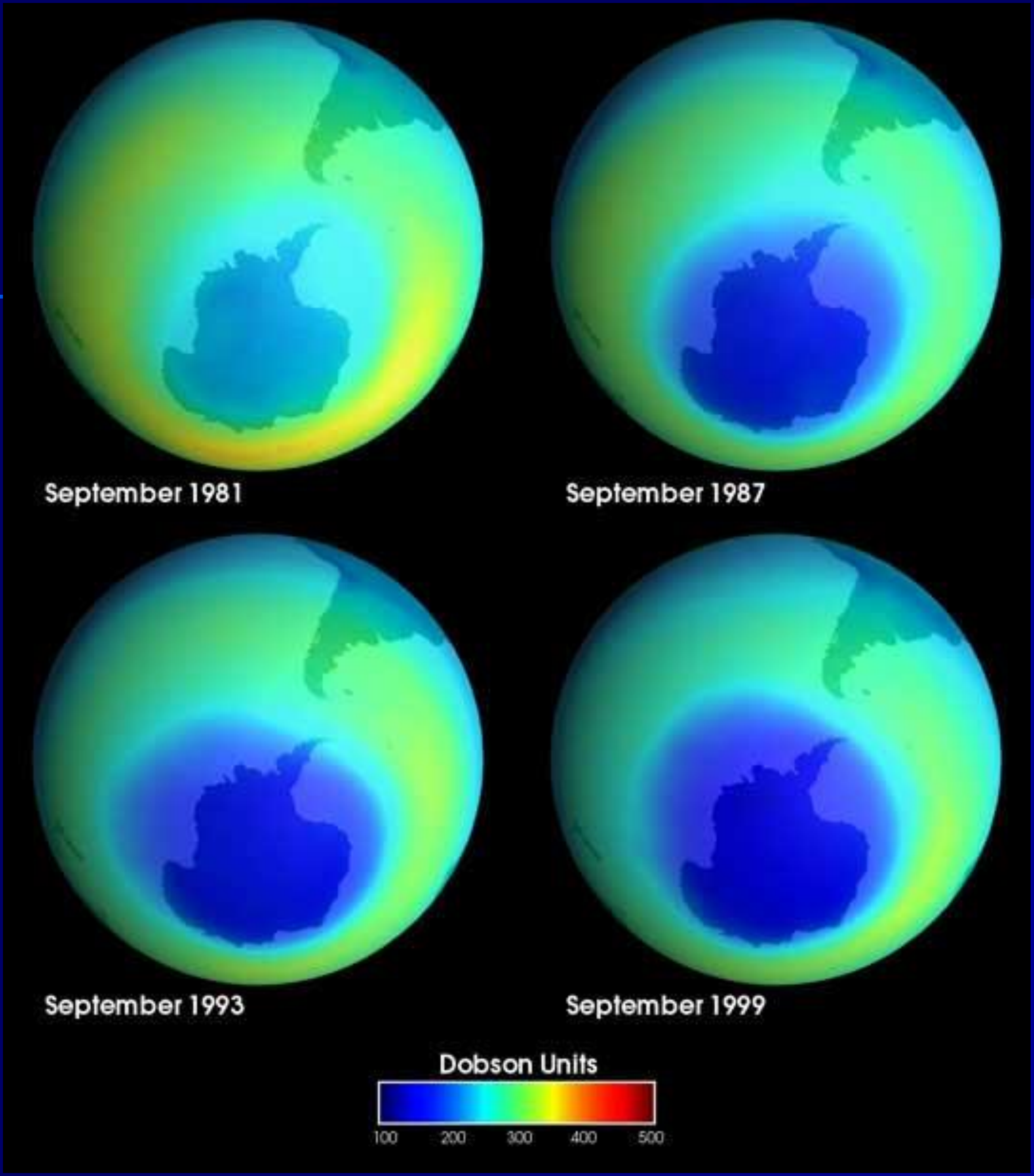
The “Ozone Hole”

– What is the “ozone hole?” When did it first appear? How does it form?



The ozone hole is the region over Antarctica with total ozone 220 Dobson Units or lower. (The avg total column ozone in the atmosphere is about 300 DU.)

Ozone hole in Sept 2005. Source: NASA


September 1981
September 1987
September 1993
September 1999
Dobson Units
100
200
300
400
500

Regulation

In 1978, the United States, Canada and Norway enacted bans on CFC-containing aerosol sprays that are thought to damage the ozone layer. The European Community rejected an analogous proposal to do the same.

In the U.S., chlorofluorocarbons continued to be used in other applications, such as refrigeration and industrial cleaning, **until after the discovery of the** Antarctic **ozone hole in 1985**.

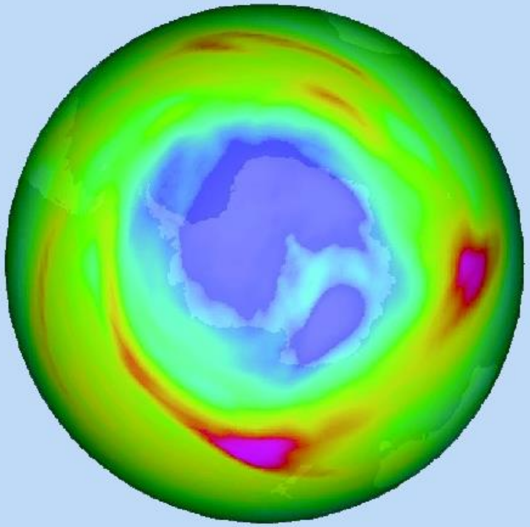
After negotiation of an international treaty (**the Montreal Protocol**), CFC production was sharply limited beginning in 1987 and phased out completely by 1996.

Since that time, the treaty has been amended to ban CFC production **after 1995 in the developed countries, and later in developing. Today, over 160 countries have signed the treaty**.

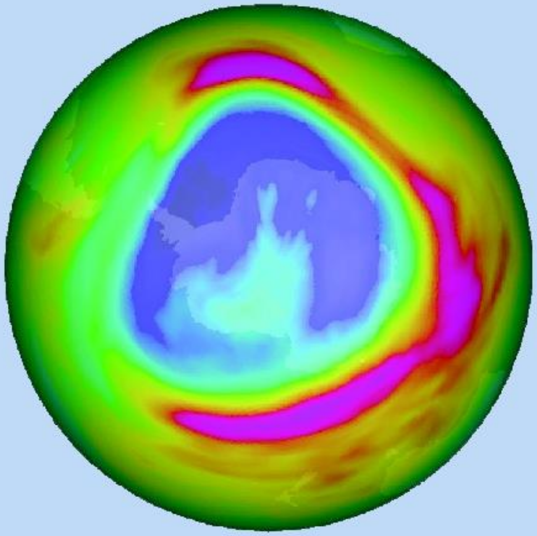
NASA Observations Confirm Expected Ozone Layer Recovery

NASA satellite observations have provided the first evidence the rate of ozone depletion in the Earth's upper atmosphere is decreasing. This may indicate the first stage of ozone layer recovery.

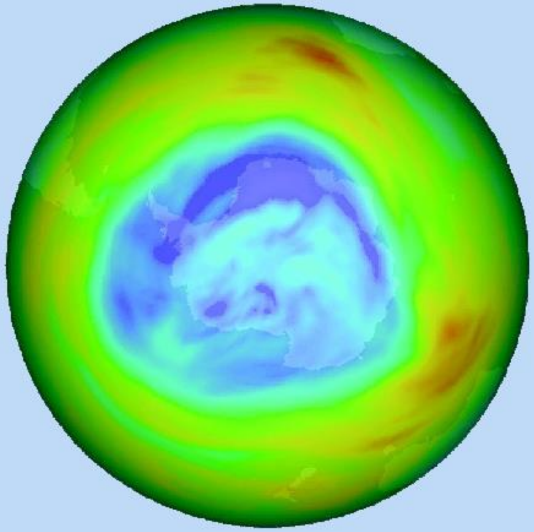
9 September 2006



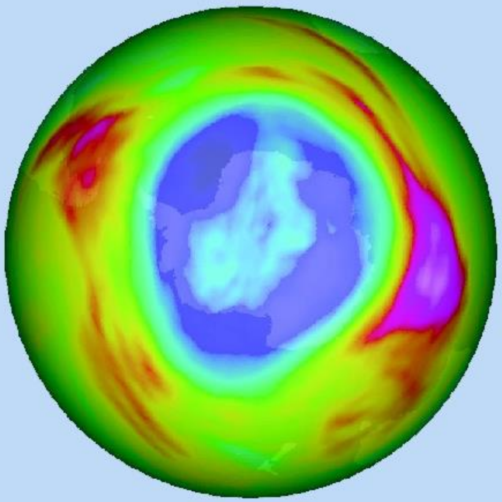
9 September 2007



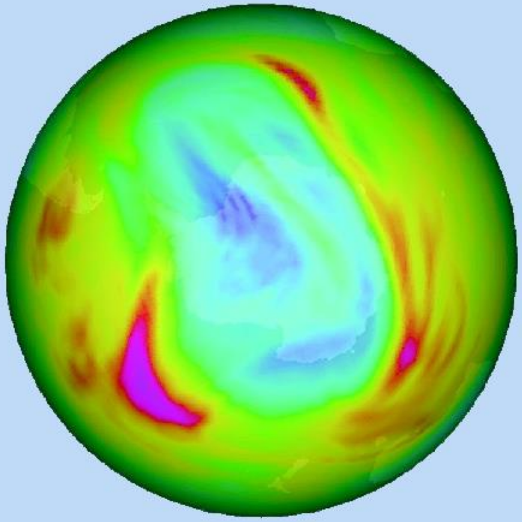
9 September 2008

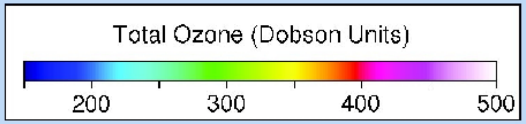


9 September 2009



9 September 2010





macc
Monitoring atmospheric composition & climate

Earth Atmosphere

Retaining of Gases in the Earth
Major / Minor constituents
Barometric Equation
Scale Height
Number Density Profiles
Temperature Profiles
Atmospheric Regions
Retaining of Gases

Global Warming

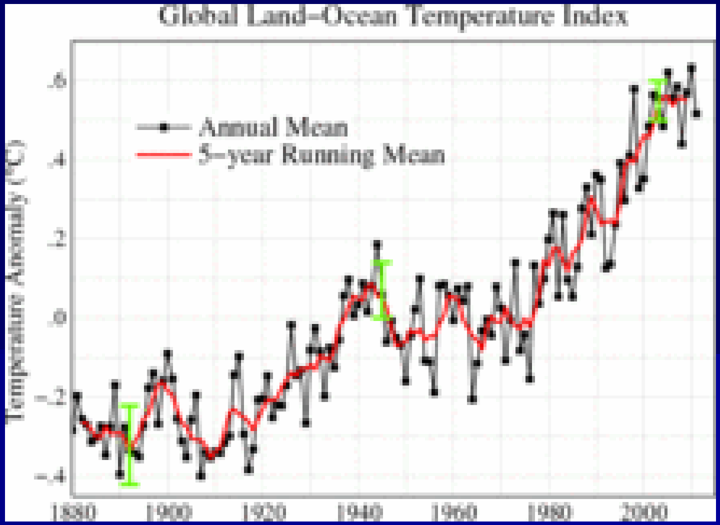
Global Warming

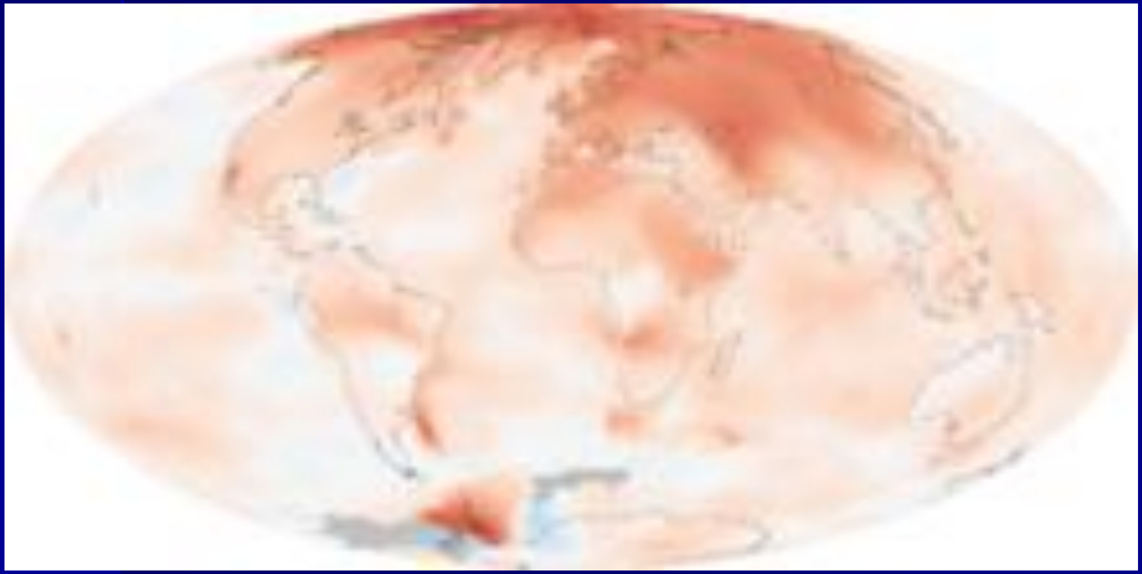
Global warming is the rise in the average temperature of Earth's atmosphere and oceans since the late 19th century and its projected continuation.

Since the early 20th century, Earth's mean surface temperature has increased by about 0.8 °C, with about two-thirds of the increase occurring since 1980.

Global Warming

Global mean land-ocean temperature change from 1880–2011, relative to the 1951–1980 mean. The black line is the annual mean and the red line is the 5-year running mean. The green bars show uncertainty estimates. (Source: NASA GISS)





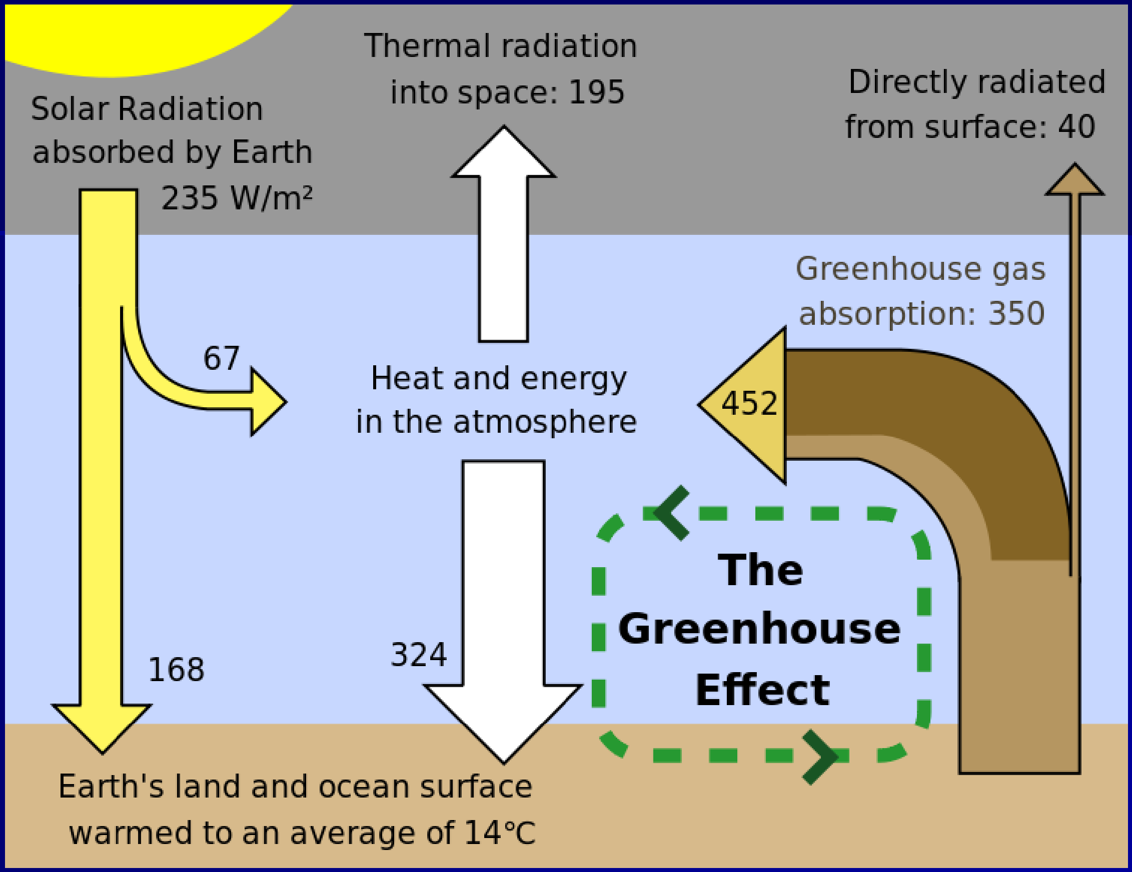
The map shows the 10-year average (2000–2009) global mean temperature anomaly relative to the 1951–1980 mean.

The **largest temperature increases are in the Arctic and the Antarctic Peninsula**. Source: NASA Earth Observatory

Initial causes of temperature changes

Greenhouse gases :

The greenhouse effect is the process by which absorption and emission of infrared radiation by gases in the atmosphere warm a planet's lower atmosphere and surface.



Naturally occurring amounts of greenhouse gases have a mean warming effect of about 33 °C (59 °F). The major greenhouse gases are **water vapor**, which causes about 36–70% of the greenhouse effect; **carbon dioxide** (CO2), which causes 9–26%; **methane** (CH4), which causes 4–9%; and **ozone** (O3), which causes 3–7%. Clouds also affect the radiation balance through cloud forcing similar to greenhouse gases.

Initial causes of temperature changes

Particulates (අංශු) and soot (දැලි)

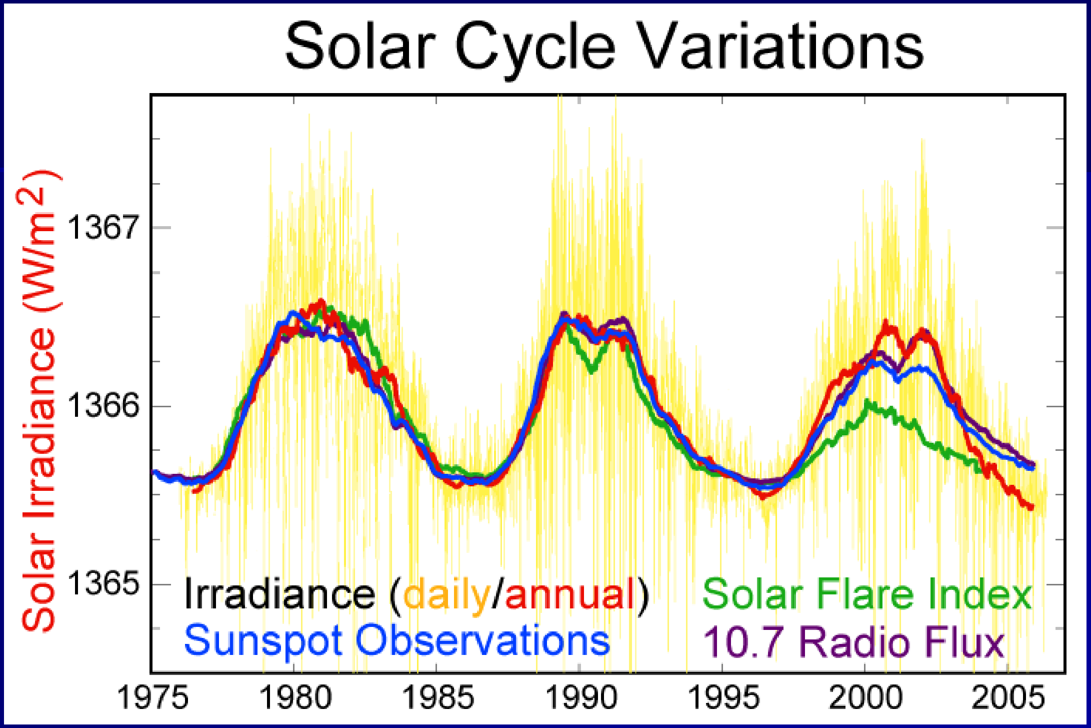
Global dimming, a gradual reduction in the amount of global direct irradiance at the Earth's surface, was observed from 1961 until at least 1990. The main cause of this dimming is particulates (**අංශු**) produced by volcanoes and human made pollutants, which exerts a cooling effect by increasing the reflection of incoming sunlight.

Soot (දැලි) may cool or warm the surface, depending on whether it is airborne or deposited. Atmospheric soot directly absorb solar radiation, which heats the atmosphere and cools the surface. In isolated areas with high soot production, such as rural India, as much as 50% of surface warming due to greenhouse gases may be masked by atmospheric brown cloud.

Initial causes of temperature changes

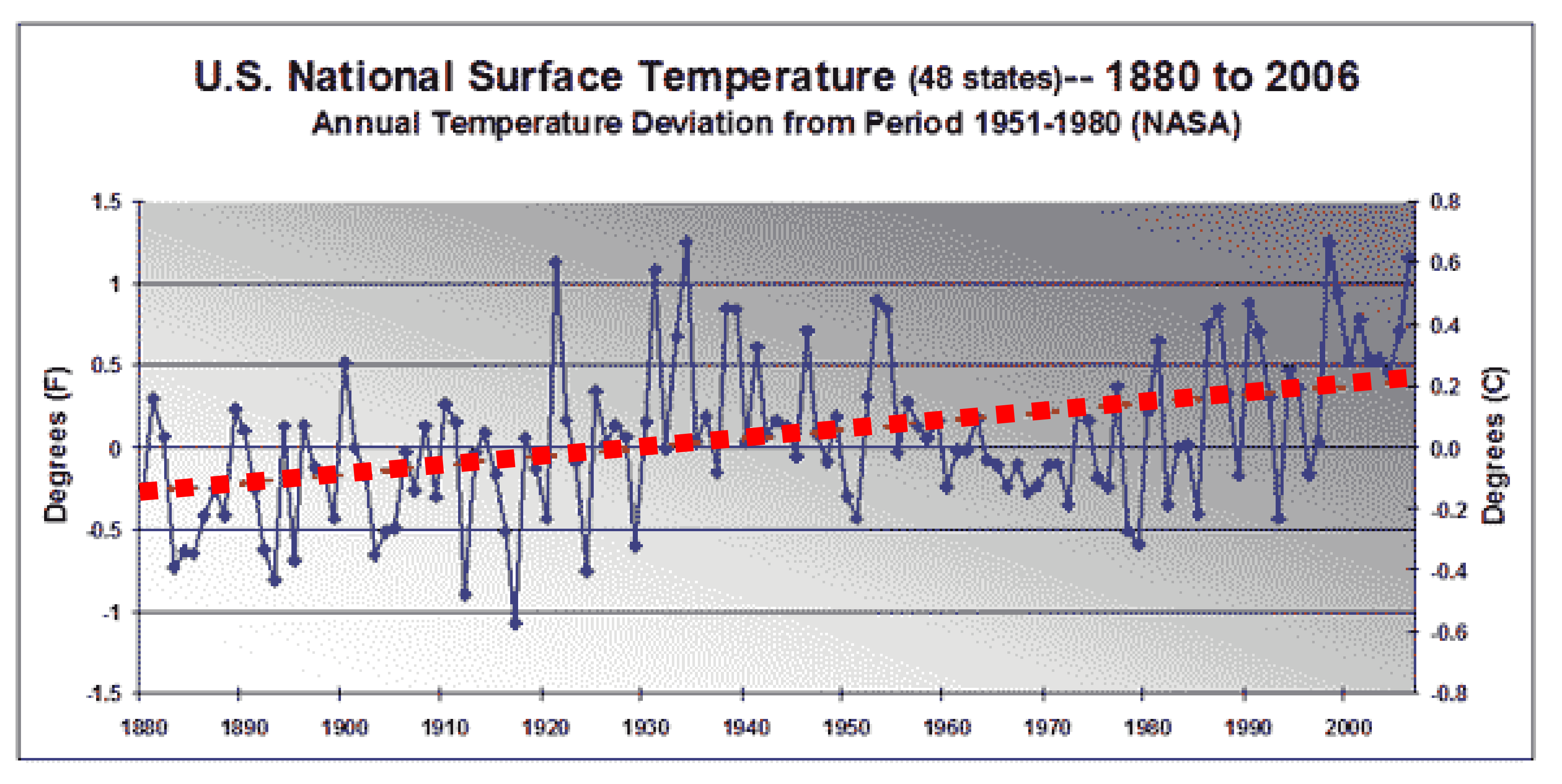
Solar activity

Solar variations causing changes in solar radiation energy reaching the Earth have been the cause of past climate changes. The effect of changes in solar forcing in recent decades is uncertain, but small, with some studies showing a slight cooling effect, while others studies suggest a slight warming effect.



Studies in 2011 have indicated that solar activity may be slowing, and that the next solar cycle could be delayed. To what extent is not yet clear; Solar Cycle 25 is due to start in 2020, but may be delayed to 2022 or even longer.

Global Warming



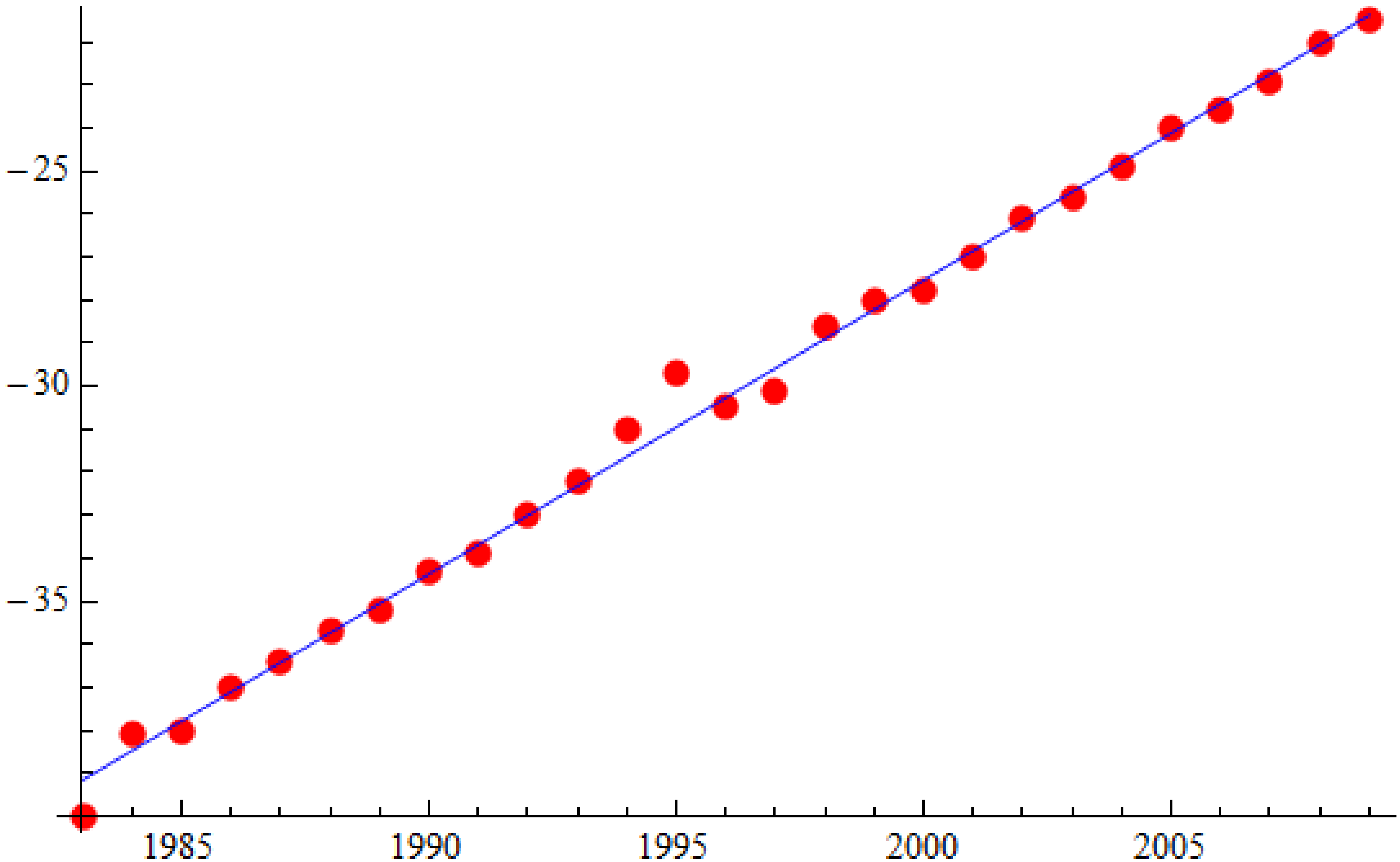
- There is a **future threat of melting the glaciers in the polar regions of the Earth** as a consequence of global warming. Ecologists have **predicted that before the end of year 2050, the glaciers in the Polar Regions will melt entirely**. The following table depicts the variation of the temperature and the prevailed carbon dioxide percentage of the environment with time for the last 27 years in the Arctic region of the earth. Values given here are the annual averages of daily records.

P. T. O…

Year	1983	1984	1985	1986	1987	1988	1989	1990	1991
Average Temperature (°C)	-40.0	-38.1	-38.0	-37.0	-36.4	-35.7	-35.2	-34.3	-33.9
Environment CO_2 percentage	0.5	1.0	1.9	2.0	3.0	3.9	4.2	5.0	5.2

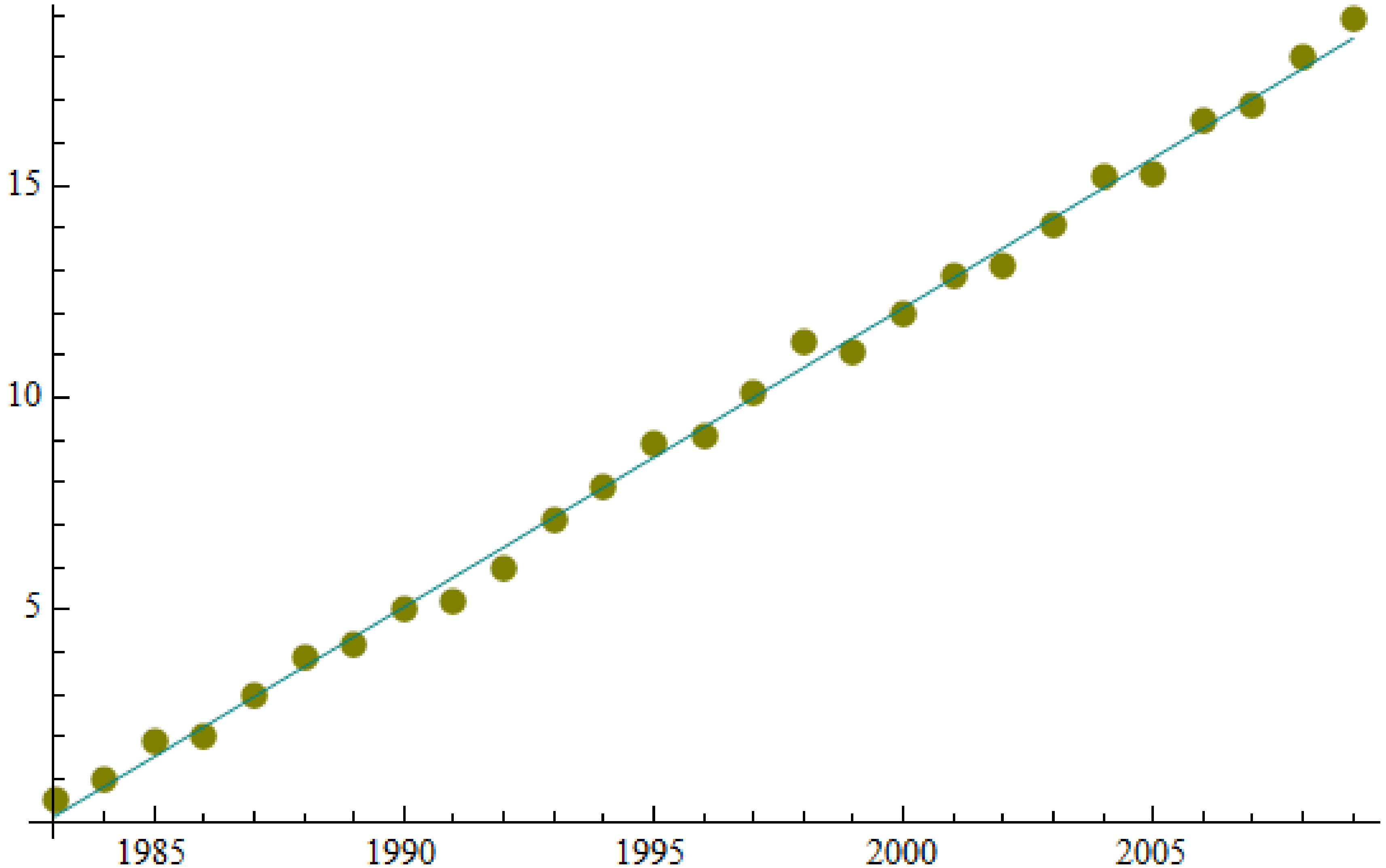
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000
Average Temperature (°C)	-33.0	-32.2	-31.0	-29.7	-30.5	-30.1	-28.6	-28.0	-27.8
Environment CO_2 percentage	6.0	7.1	7.9	8.9	9.1	10.1	11.3	11.1	12.0

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009
Average Temperature (°C)	-27.0	-26.1	-25.6	-24.9	-24.0	-23.6	-22.9	-22.0	-21.5
Environment CO_2 percentage	12.9	13.1	14.1	15.2	15.3	16.5	16.9	18.0	18.9



The Temperature w.r.t time : $-1395.66 \boxed{+ 0.684066}\, t$

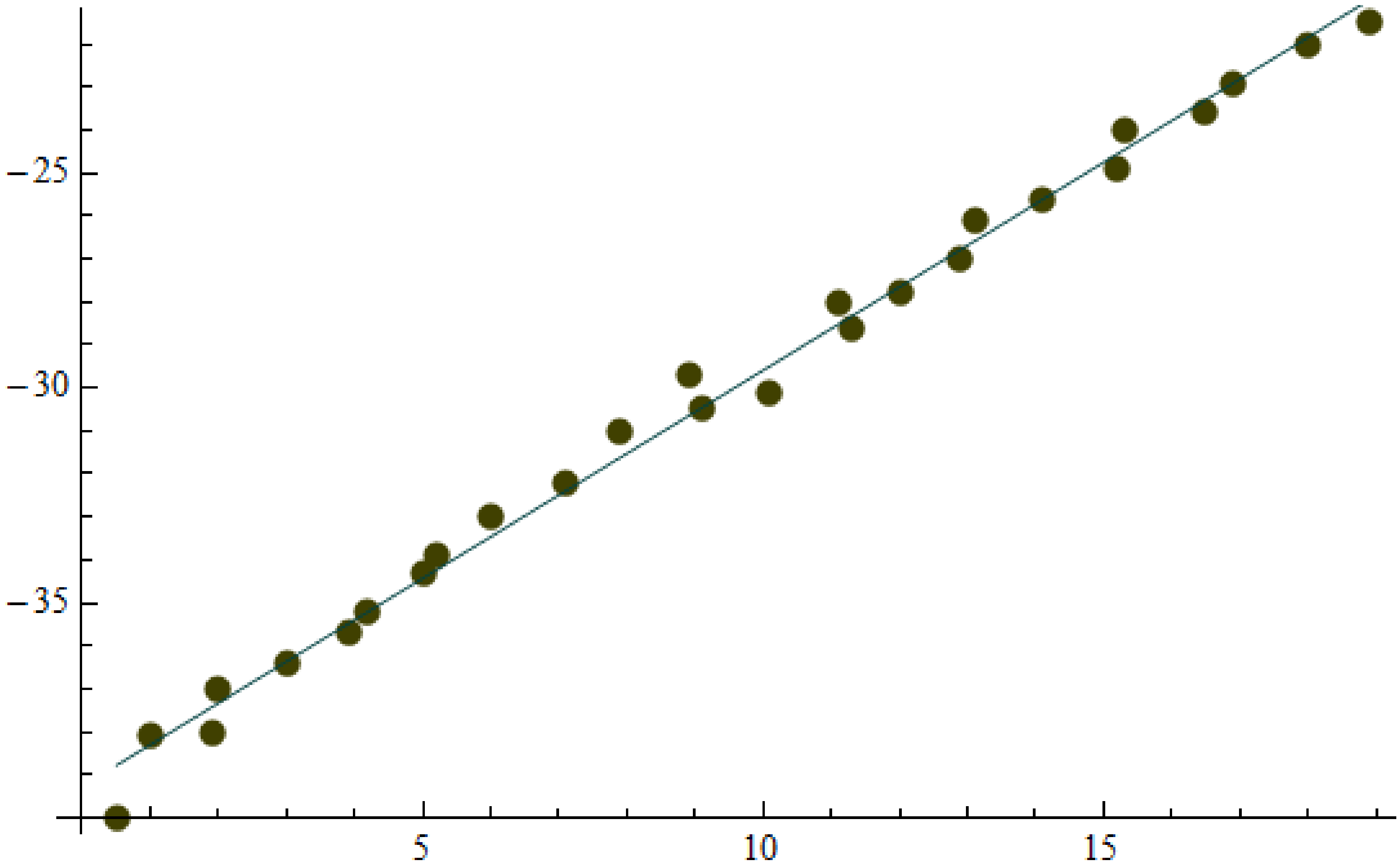
The Temperature will be zero on : $\{\{t \to 2040.24\}\}$



The CO2 % w.r.t time : -1397.77 + 0.704945 t

The CO2 % on year 2040: 40.3176 %

The Temperature % w.r.t CO2 % : -39.2642 + 0.967879 x

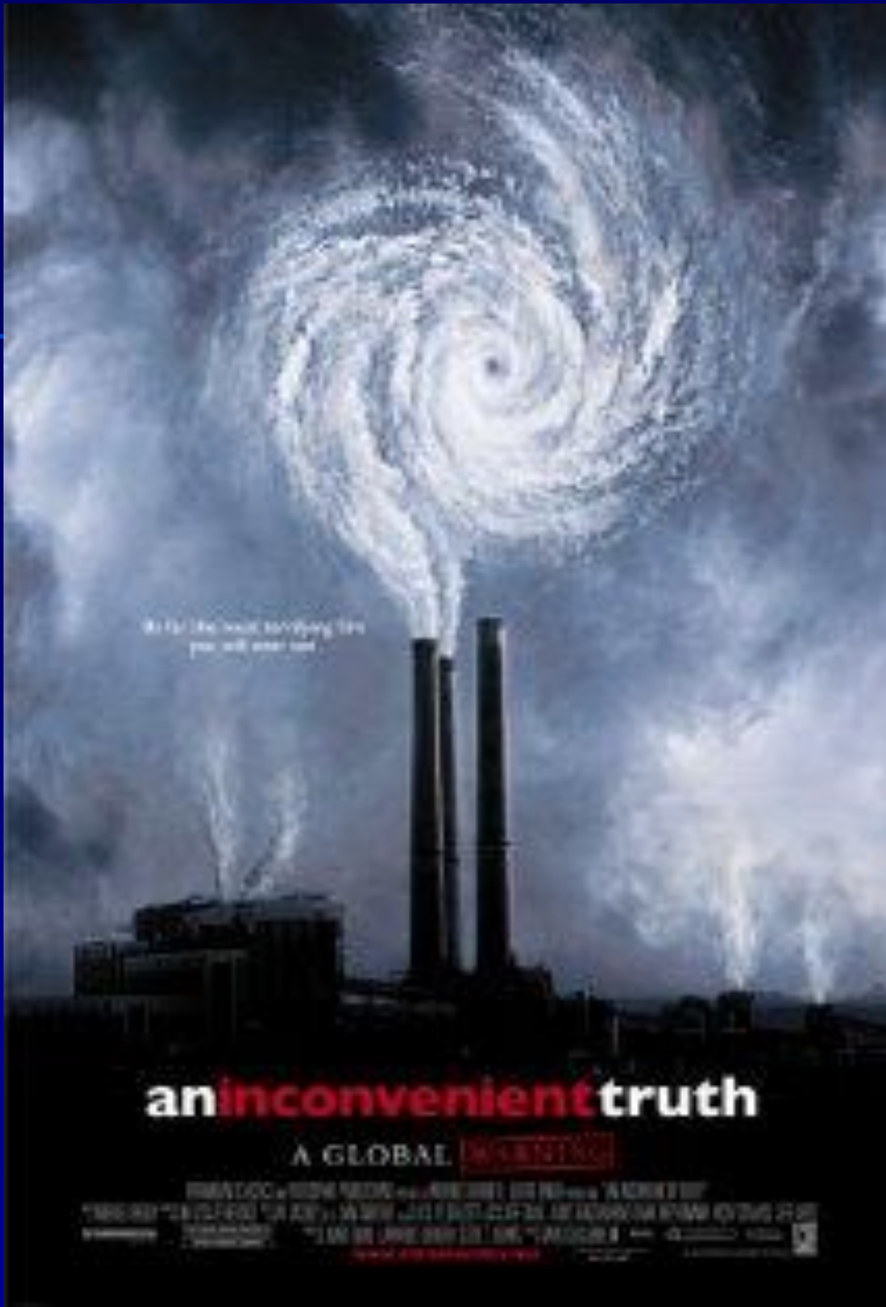


The Temperature and w.r.t CO2 has a LINEAR RELATIONSHIP !

The Nobel Peace Prize 2007

Intergovernmental Panel on Climate Change , Al Gore

The Nobel Peace Prize 2007 was awarded jointly to Intergovernmental Panel on Climate Change (IPCC) and Albert Arnold (Al) Gore Jr. *"for their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change"*



An Inconvenient Truth

en.wikipedia.org

An Inconvenient Truth is a 2006 documentary film directed by Davis Guggenheim about former United States Vice President Al Gore's campaign to educate citizens about global warming via a comprehensive ... Wikipedia

Release date: January 24, 2006 (initial release)

Director: Davis Guggenheim

DVD release date: November 21, 2006

Awards: NAACP Image Award for Outstanding Foreign Motion Picture, More

Producers: Lawrence Bender, Laurie David, Al Gore

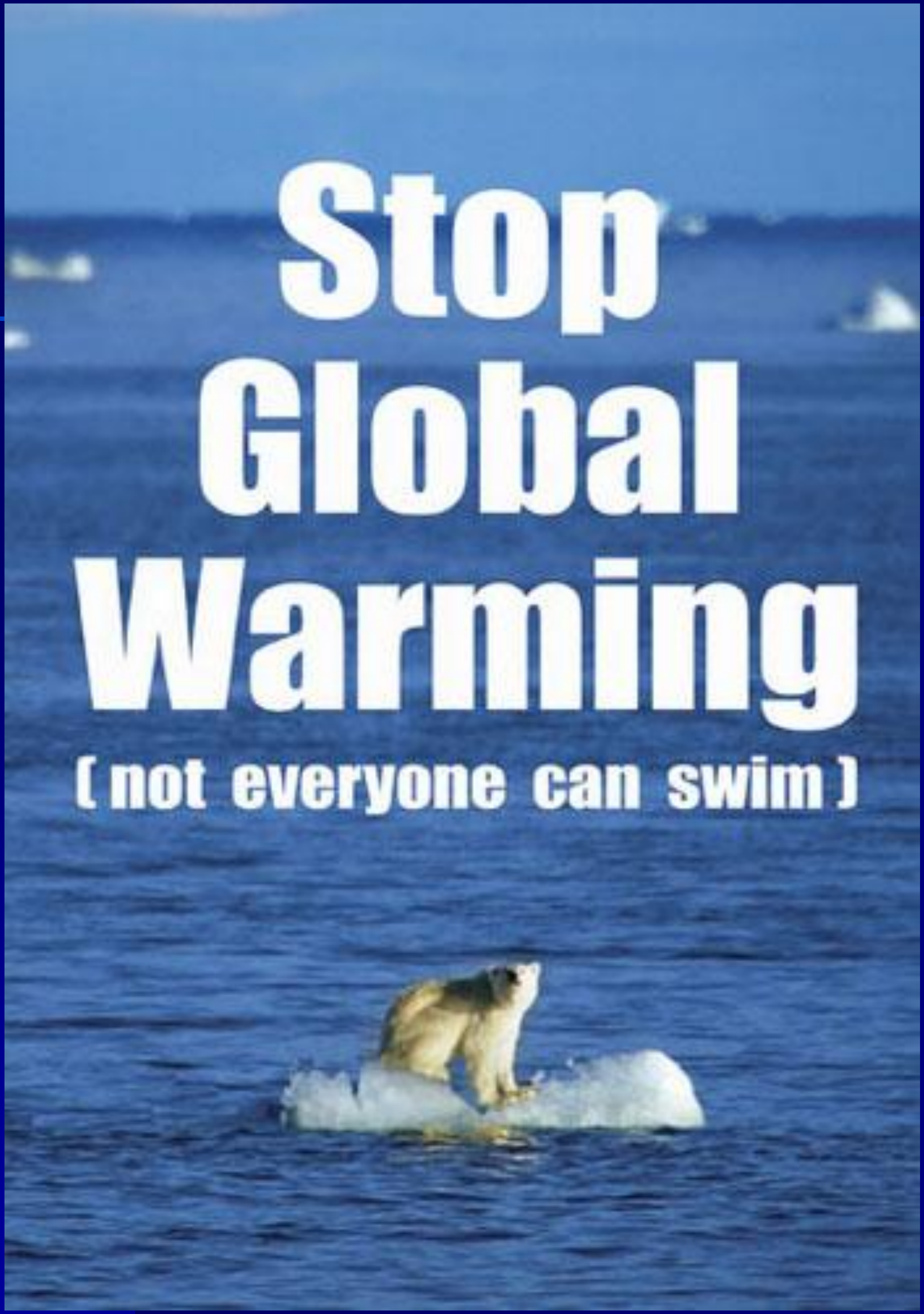
Cast: Al Gore, Billy West

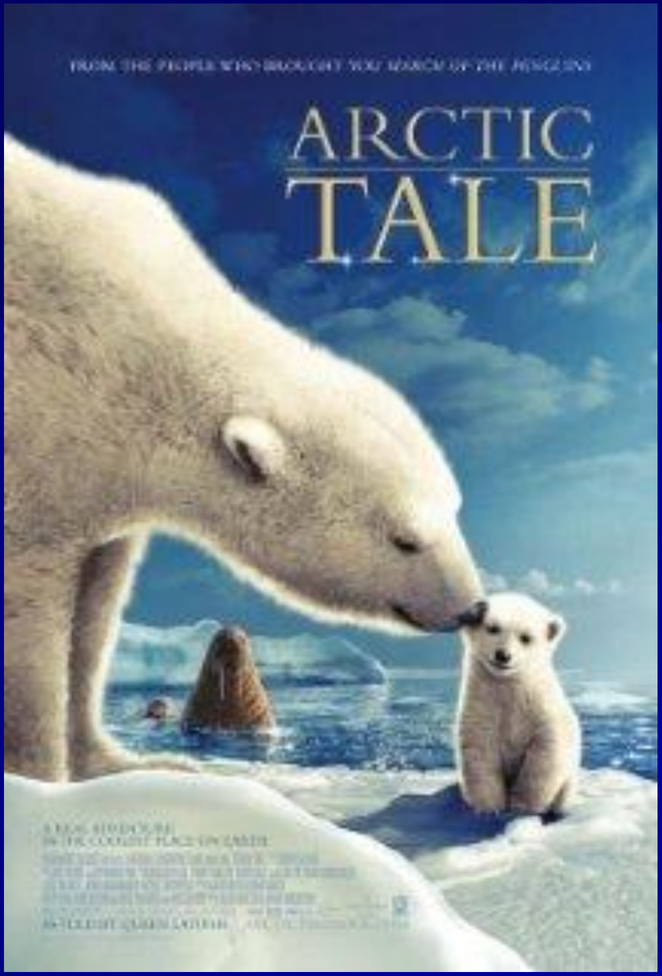
A documentary on Al Gore's campaign to make the issue of global warming a recognized problem worldwide.

"It is now clear that we face a deepening global climate crisis that requires us to act boldly, quickly, and wisely," said Gore.

An Inconvenient Truth (2006)

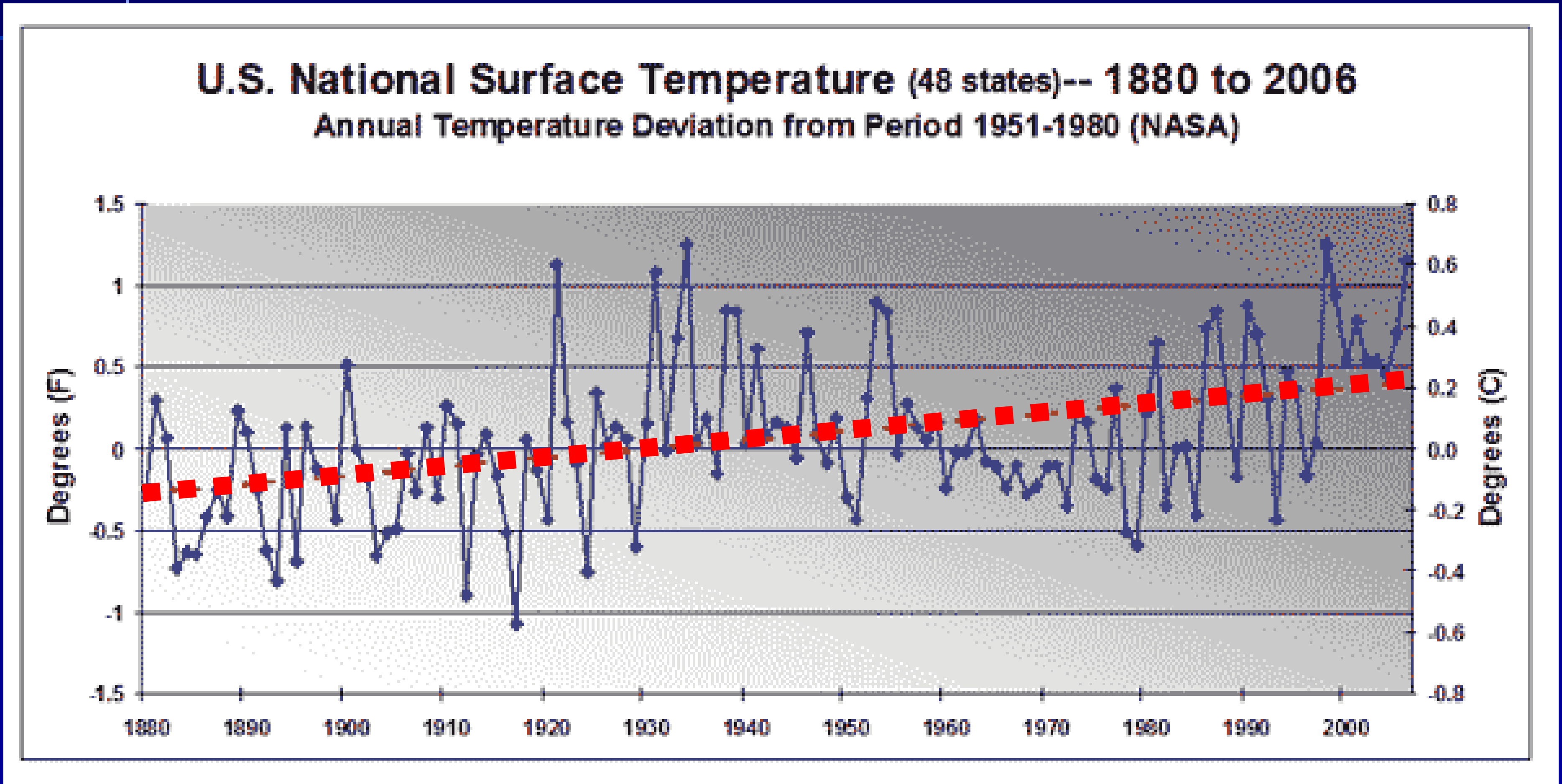
Oscar-winning documentary about the environment featuring the unlikeliest of movie stars. Former presidential candidate Al Gore holds this film together as, in front of an audience and with few aids beyond photo slides, he explains how humans have messed up the planet. Gore issues an urgent warning on what must be done, and done quickly, to save the earth.

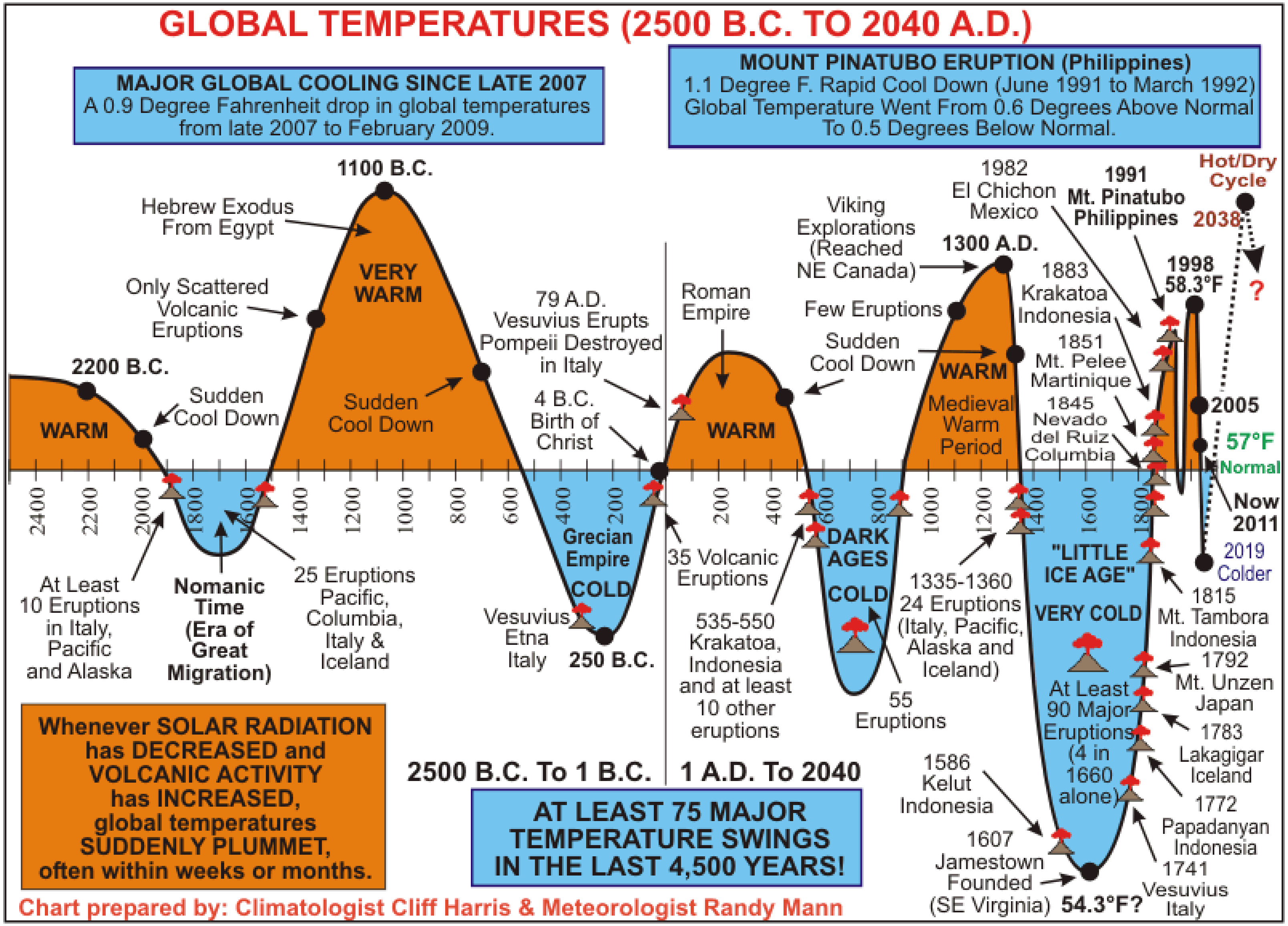




Two narratives -- the life cycle of a mother walrus and her calf, and the life of a polar bear and her cubs -- are used to illustrate the harsh realities of existence in the Arctic.

Global Warming





Global temperature chart was complied by Climatologist Cliff Harris that combined the following resources:

"Climate and the Affairs of Men" *by Dr. Iben Browing.*

"Climate...The Key to Understanding Business Cycles...The Raymond H. Wheeler Papers. *By Michael Zahorchak*

Weather Science Foundation Papers in Crystal Lake, Illinois.

Top 10 Things You Can Do to Reduce Global Warming

1. **Reduce**, **Reuse**, **Recycle**
2. **Use Less Heat and Air Conditioning**
3. **Change a Light Bulb** (CFL, most suitable LED Bulbs)
4. **Drive Less and Drive Smart**
5. **Buy Energy-Efficient Products** (Plasma Display, CRT Display, **LCD**, **LED, OLED**)
6. **Use Less Hot Water**
7. **Use the "Off" Switch**
8. **Plant a Tree**
9. **Get a Report Card from your Utility Company**
10. **Encourage Others to Conserve**

Share information about recycling and energy conservation with your friends, neighbors and co-workers, and take opportunities to encourage public officials to establish programs and policies that are good for the environment.

These 10 steps will take you a long way toward reducing your energy use and your monthly budget. And less energy use means less dependence on the fossil fuels that create greenhouse gases and contribute to global warming.

Thank You !