

## 1. Details of Module and its structure

Module Detail	
Subject Name	Geography
Course Name	Geography 01 (Class XI, Semester - 1)
Module Name/Title	World Climate – Part 1
Module Id	kegy_11202
Pre-requisites	General understanding of world climate and climate change
Objectives	This lesson will make you understand- <ul style="list-style-type: none"><li>• Enumerate the causes of global warming, explain global warming,</li><li>• Tell the effects of global warming,</li><li>• Assess the need to tackle global warming,</li><li>• Figure out the remedies to reduce this problem</li></ul>
Keywords	Global warming, Dendrochronology, Terrestrial, Anthropogenic, Greenhouse gases, Ozone

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## **Table of Content:**

1. Introduction
2. Climate in the recent past Causes of Climate Change Global Warming
3. Conclusion

We have been observing very keenly that the weather conditions are erratic in recent years. You must be remembering that the winter of this year (December 2016 to February 2017) was very warm in many previous years. Probably this winter was warmest in recorded history. Droughts as well as floods are now-a-days frequently occurring phenomena. Climate is the overall average conditions of all weather related components for larger areas/ regions over a long duration. There is wide departure of these components from the normal conditions and the deviations are growing exponentially in the recent past.

According to report of Intergovernmental Panel on Climate Change (IPCC), Earth's average temperature has risen by 1.5°F from 1880 to 2012 and it is projected to rise another 0.5°F to 8.6°F over the next hundred years. The future projection in increase in temperature is dependent upon the intensity of the release of greenhouse gases the efforts taken by the governments/ people in general and the reality in particular. Small changes in the average temperature of the planet can translate to large and potentially dangerous shifts in climate and weather. Figure 1 shows the temperature since 1880 till recent time. It is quite evident that the temperature is increasing and this increase is very drastic. The five-year average temperature is clearly showing the rising trend with minor lowering temperature. But overall, global average temperature has risen by 0.51°C in a span of only 130 years. Generally the air temperature is recorded under shadow and well ventilated space, Stevenson screen. When we say global temperature rise, it is the temperature of the air. The volume of the atmosphere is a huge one considering the size of the earth. Therefore, half degree centigrade temperature of such a huge body and that to in such a small period is a great concern for the survival of various types of biotic life.

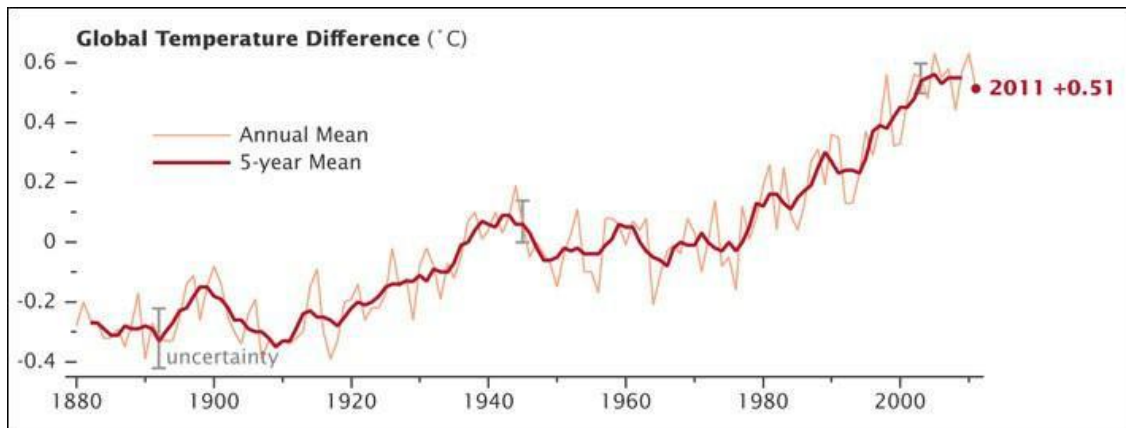


Figure 1: Trends in temperature rise

Source: [https://climate.nasa.gov/images/616910main\\_gisstemp\\_2011\\_graph\\_lrg.jpg](https://climate.nasa.gov/images/616910main_gisstemp_2011_graph_lrg.jpg)

### Clear evidences

Rising global temperatures have been accompanied by changes in weather and eventually lead to change in climate. Many places have experienced changes in rainfall pattern. It is resulting in intense rainfall leading to greater floods, severe droughts, melt and retreat of glaciers as well as more frequent and severe heat waves. The oceans and glaciers have also experienced some big changes. The air, land and ocean are getting warmed up. Water bodies are becoming more acidic. Ice caps are melting, and sea level is rising. All these changes and other related changes are more pronounced in recent decades. They are greater challenges to to our society and our environment in general and for all sorts of lives in particular on our living planet.

The Earth's atmosphere is dynamic and has been changing ever since it came into being after the birth of the Earth. Accordingly, global climatic changes have occurred both in geological and historical times. Climatic fluctuations have taken place varying from a few years to million years. Over a long period of time, the prevailing climate over a particular large area has witnessed a drastic change. This change in climate is called Climate Change.

There are several evidences which show that the climatic changes have taken place. The type of climate we experience now might be prevailing over the last 10,000 years with minor and occasionally wide fluctuations. The planet earth has witnessed many variations in climate since the beginning. Geological records show alteration of glacial and inter-glacial periods.

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This sort of climatic change was probably because of natural causes. But the climate change we observe today is more of a man-made than a natural. This phase of changing climate is due to our own activities. That why, it said that the current climate change has its genesis in the anthropogenic activities. The geomorphological features, especially in high altitudes and high latitudes, exhibit traces of advances and retreats of glaciers. The sediment deposits in glacial lakes also reveal the occurrence of warm and cold periods. The rings in the stems of tree provide clues about wet and dry periods during their growth. We call it a study of dendrochronology.

Dendrochronology is a science by which we used to study the rings appearing in the felled trees. These rings are studied to determine the present climate particularly the dry and wet conditions. Based on this study a climatic reconstruct is made for the past climate through which that particular tree under study has passed by. During the life span of a tree, the available moisture/ precipitation for the utilization of the tree is recorded by the growth and development of rings. Wet period/ more precipitation is marked by thicker growth of the ring as sufficient food is prepared by the tree while the thinner ring is developed when the season is witnessed by lesser moisture. This method is very useful in determining the changing climate in a shorter span.

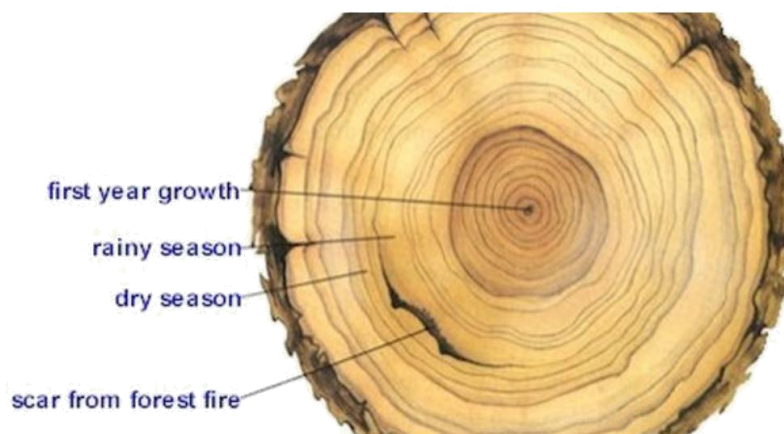


Figure 2: Dendrochronology and climate change

Source: <https://s-media-cache-ak0.pinimg.com/600x315/58/6d/63/586d630259ecef105c0970bfd8f3d297.jpg>

Historical records describe the vagaries in climate. All these evidences indicate that change in climate is a natural and continuous process. India also witnessed alternate wet and dry

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periods. Archaeological findings show that the Rajasthan desert experienced wet and cool climate around 8,000 B.C. The period 3,000-1,700 B.C. had higher rainfall. From about 2,000-1,700 B.C. This region was the Centre of the Harappa civilization. Such a large scale and well developed civilization is not possible to flourish in a prevailing climatic conditions of today. Since then, dry conditions accentuated. It is a very apt example of climate change that is visible today.

In the geological past, the earth was warm some 500-300 million years ago, through the Cambrian, Ordovician and Silurian periods. During the Pleistocene epoch, glacial and inter-glacial periods occurred, the last major peak glacial period was about 18,000 years ago. The present inter-glacial period started 10,000 years ago.

### **Climate in the recent past**

Variability in climate is observed all the time. Climatic changes in geological and historical past have taken place. Extreme weather events have occurred in the recent past some of the examples. The 1990s has witnessed extreme weather events. This period has witnessed the warmest temperature of the 20<sup>th</sup> century and some of the worst floods around the world. The worst devastating drought in the Sahel region, south of the Sahara Desert, from 1967-1977 is fine example of changing climate.

During the 1930s, severe drought occurred in southwestern Great Plains of the United States, described as the dust bowl. Historical records of crop yield or crop failures, floods and migration of people tell about the effects of changing climate. A number of times Europe witnessed warm, wet, cold and dry periods. The significant episodes were the warm and dry conditions in the tenth and eleventh centuries when the Vikings settled in Greenland. Europe witnessed 'Little Ice Age' from 1550 to about 1850. From about 1885-1940 world temperature showed an upward trend. After 1940, the rate of increase in temperature slowed down but after mid-1960s, it is almost continuously on rise (Figure 1).

### **Causes of Climate Change**

There are several causes for climate change like sunspot and solar cycle, forest fire, volcanic eruption, deforestation, industrialization, urbanization, burning of fossil fuel etc. These important causes can be grouped into:

- Astronomical causes
- Terrestrial causes
- Anthropogenic causes.

**Astronomical Causes:** The astronomical causes of climate change are the changes in solar output associated with sunspots appearing on the sun's surface called photosphere. Sunspots are dark and cooler patches on the sun which increase and decrease in a cyclical manner. According to some meteorologists, when the number of sunspots increases, cooler weather is observed on the earth as the incoming solar radiation is lesser. A decrease in sunspots is associated with greater amount of solar radiation received on the earth. Hence, warmer and drier conditions are resulted. Yet, these findings are not very much statistically significant. In fact, the solar cycle has been under study since 1755 A.D. A solar cycle is, on an average, of 11.7 years. In another words, the sunspots are observed in a cyclic manner. If we calculate the solar sunspot cycle, it is very easy by taking 11.7 years with little plus or minus. Since 1755, 24<sup>th</sup> cycle is supposed to be completed by the year 2020. Study the Figure 3. You will find that out of three cycles shown 24<sup>th</sup> cycle has lesser number of sunspots. The 22<sup>nd</sup> cycle has relatively large numbers of sunspots. Therefore, from mid-1980s to mid-1990s has mild temperature in comparison to the 24<sup>th</sup> cycle – from about 2010 to around 2020. It is 2017 and we have observed warmer winter. The temperature received is more and hence, warmer and dryer conditions are prevailing.

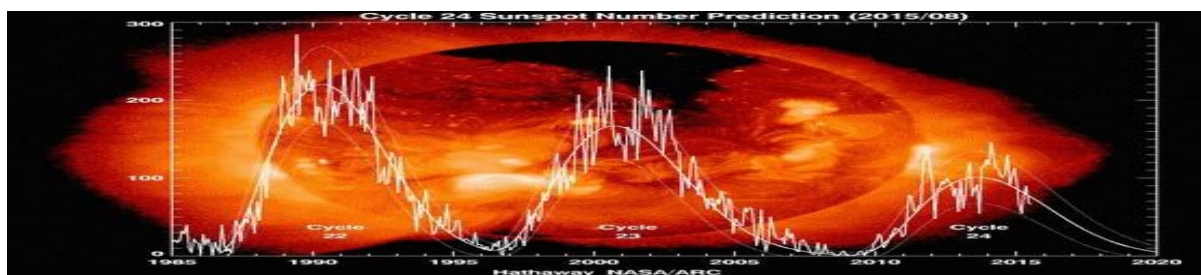


Figure 3: Sunspots and energy release

Source: [https://upload.wikimedia.org/wikipedia/commons/5/5e/Solar\\_Cycle\\_Prediction.gif](https://upload.wikimedia.org/wikipedia/commons/5/5e/Solar_Cycle_Prediction.gif)

Another astronomical theory is Millankovitch oscillations, which infer cycles in the variations in the earth's orbital characteristics around the sun, the wobbling of the earth and the changes in the earth's axial tilt. Today the earth's axis is tilted to around  $23.5^{\circ}$ . It is estimated that its change in the tilt of the axis may vary from  $22.2^{\circ}$  to  $24.5^{\circ}$ . Greater tilt is associated with lesser elliptical path around. It leads to more temperature recording on the

earth. Smaller tilt in the axis of the earth is translated into greater elliptical path. Therefore, it is the cause of lesser insolation received. This causes the global cooling. The change in the axis is almost found in a periodicity of about 41000 years. All these alter the amount of insolation received from the sun, which in turn, might have a bearing on the climate.

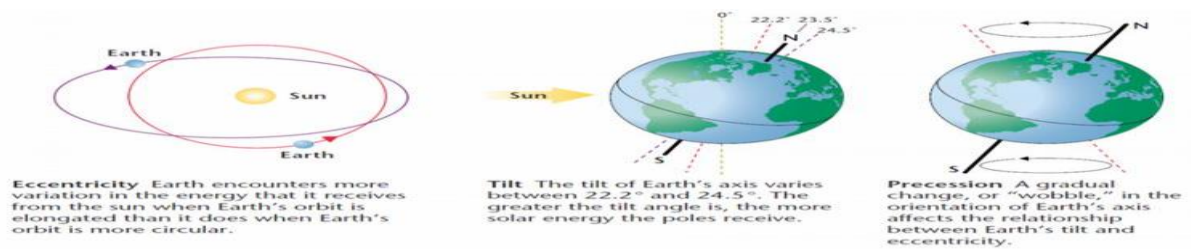


Figure 4: Tilt of earth's axis vs elliptical orbit and received energy

Source: <https://rodboroughgeog.files.wordpress.com/2016/10/milankovitch.png?w=900>

**Terrestrial causes:** The term terrestrial is concerned with earth. Under this category, all aspects are included which is responsible for rising temperature associated with earth. Volcanism is one such incident linked directly from the earth. At the time of volcanic eruptions, hot magmatic materials are ejected from the inner part of the earth. In this process, enormous heat is generated coming from interior and is released. This leads to warm the atmospheric condition at the local level and it is a direct cause for rise in temperature rise.

Apart from the release of heat, volcanism is also the cause for lots of aerosols into the atmosphere. These aerosols remain in the atmosphere for a considerable period of time. Their presence in the atmosphere reduces the sun's radiation reaching the earth's surface. Reduction in radiation at the surface may cause for cool weather conditions. After the recent Pinatoba and El Cion volcanic eruptions, the average temperature of the earth fell to some extent for some years. In April 1982 at El Chichon and in June 1991 at Pitatubo (in Mexico) volcanic eruption occurred. The same is shown in Figure 5. From this figure, it is very clear that the large scale volcanic eruption reduces the global sunlight received over a very large part of the globe.



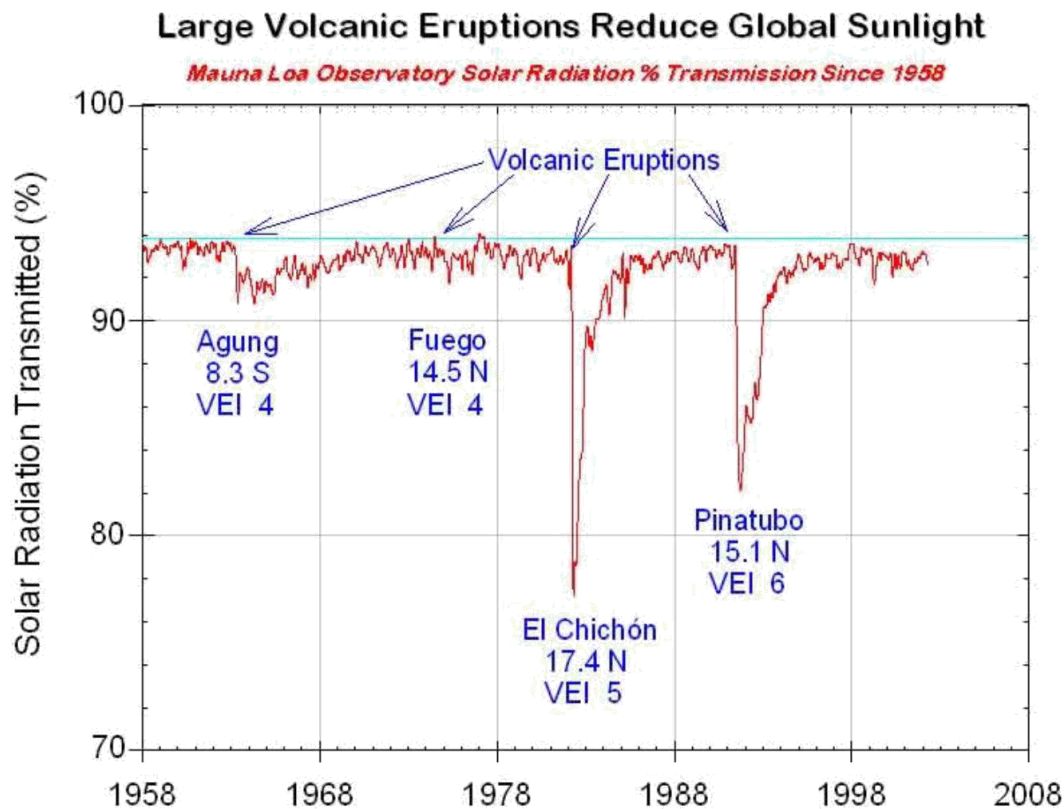


Figure 5: Important volcanic eruptions and their effect on solar radiation

Source: [https://www.esrl.noaa.gov/gmd/obop/mlo/programs/esrl/solar/img/img\\_solar\\_radiation\\_transmission.jpg](https://www.esrl.noaa.gov/gmd/obop/mlo/programs/esrl/solar/img/img_solar_radiation_transmission.jpg)

**Anthropogenic Causes:** As the name suggests, it includes those factors which are caused by human beings and are leading to global temperature rise. They are more pronounced by the technologically advanced man. Basically, the use of these technology as well as the way of life are more responsible to cause more harm. Some of the climate changes are the results of unwanted human activities. The most important anthropogenic effect on the climate is the increasing trend in the concentration of greenhouse gases in the atmosphere which is likely to cause global warming. Some of the human activities leading to release of greenhouse gases are burning of wood, coal, fossil fuels, forest fire, deforestation, agricultural practices, rapid industrialization, urbanization etc. Figure 6 creates a visual impression in our mind about the harmful gases are released in the atmosphere from thermal power plant. It is a major concern towards alteration of the existing composition of atmosphere.





Figure 6: Harmful gases released by human action

Source: <http://businessnews24bd.com/wp-content/uploads/2016/09/air-pollution.jpg>

Figure 7 tells very categorically about the greenhouse gases already available in the nature and the same is increased due to human activities as well. From this figure, it is apparent that the water vapour already available in the atmosphere is the most effective factor to increase the temperature of the globe. Humans have no control over this. It is very obvious that the carbon dioxide gas has increased very alarmingly if we compare with the pre-industrial time. Human induced increase in carbon dioxide gas also increases the global temperature. You have already read that the amount of water vapour retained in the atmosphere is the function of the temperature of the air. Once the air temperature is rising, the water vapour holding capacity of the air will also rise leading to greater amount of water vapour retention in the air. It will further accentuate and will be for further increase in air temperature/ global warming. It could be minimised only by taking human action to reduce the greenhouse gases.

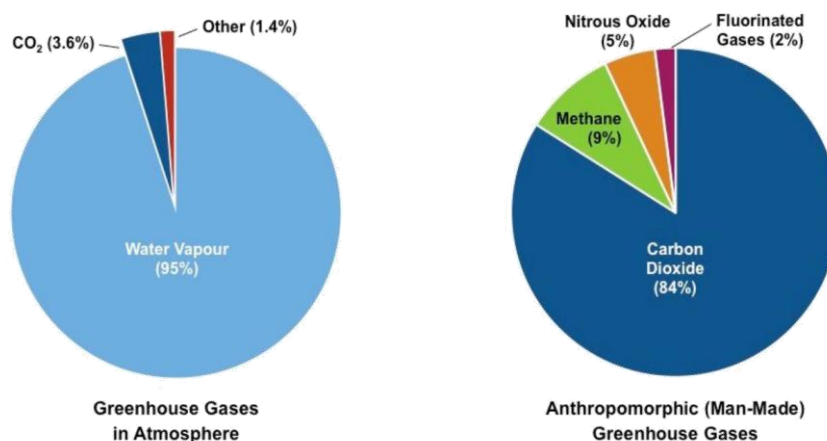


Figure 7: Contribution of natural and man-made greenhouse gases

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Source: [http://ib.bioninja.com.au/Media/greenhouse-gas-chart\\_med.jpeg](http://ib.bioninja.com.au/Media/greenhouse-gas-chart_med.jpeg)

## **Global Warming**

Due to the presence of greenhouse gases, the atmosphere is behaving like a greenhouse. The atmosphere also transmits the incoming solar radiation but absorbs the vast majority of longwave radiation emitted by the earth's surface. The gases that absorb long wave radiation are called greenhouse gases. The processes that warm the atmosphere are often collectively referred to as the greenhouse effect. The term greenhouse is derived from the analogy to a greenhouse used in cold areas for preserving heat.

A greenhouse is made up of glass. The glass which is transparent to incoming short wave solar radiation is opaque to outgoing long wave radiation. The glass, therefore, allows in more radiation and prevents the longwave radiation going outside the glasshouse, causing the temperature inside the glasshouse structure warmer than outside. When you enter a car or a bus, during summers, where windows are closed, you feel more heat than outside. Likewise, during winter, the vehicles with closed doors and windows remain warmer than the temperature outside. This is another example of the greenhouse effect.

## **Greenhouse Gases (GHGs)**

The primary GHGs of concern today are carbon dioxide (CO<sub>2</sub>), chlorofluorocarbons (CFCs), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O) and ozone (O<sub>3</sub>). Some other gases such as nitric oxide (NO) and carbon monoxide (CO) easily react with GHGs and affect their concentration in the atmosphere. The effectiveness of any given GHG molecule will depend on the magnitude of the increase in its concentration, its life time in the atmosphere and the wavelength of radiation that it absorbs.

The chlorofluorocarbons (CFCs) are highly effective. Ozone which absorbs ultra violet radiation in the stratosphere is very effective in absorbing terrestrial radiation when it is present in the lower troposphere. Another important point to be noted is that the more time the GHG molecule remains in the atmosphere, the longer it will take for earth's atmospheric system to recover from any change.

The largest concentration of GHGs in the atmosphere is carbon dioxide. With the rapid industrialization and Urbanization, the fossils fuels like coal, petroleum and natural gas are used at an accelerated rate. The emission of CO<sub>2</sub> comes mainly from fossil fuel combustion (oil, gas and coal). This has

resulted in the unprecedented increase in the carbon dioxide in the atmosphere. Under the pre-industrial conditions of recent centuries, i.e. before 1780, the carbon dioxide content of atmosphere was maintained at a reasonably low level. In 1880-1890, the carbon dioxide content was about 290 parts per million (ppm). It rose to about 315 ppm in 1980, 340 ppm in 1990 and 400 ppm in 2000. This means that the proportion of the carbon dioxide has increased by 9% by 1950 and nearly 17% by 1990.

The rate of increase has become still greater during the last decade. Assuming that the annual rate of increase of the fossil fuels is about 4%, the level of carbon dioxide will be doubled by the year 2030. However, doubling time can be delayed until about 2050 with the fuel combustion rate reduced to half of the present value.

There has been considerable increase in the methane concentration also. During past 100 years the concentration of the methane has more than doubled and carbon dioxide has increased by 20%. Global warming and environmental pollution takes place in several other ways. According to some estimates, rice cultivation in the world is responsible for 20% methane being added to the atmosphere, and the coalmining accounts for 6% of the methane. Forests and oceans are the sinks for the carbon dioxide. But, deforestation due to changes in land- use increases the concentration of carbon dioxide by 20% to the atmosphere.

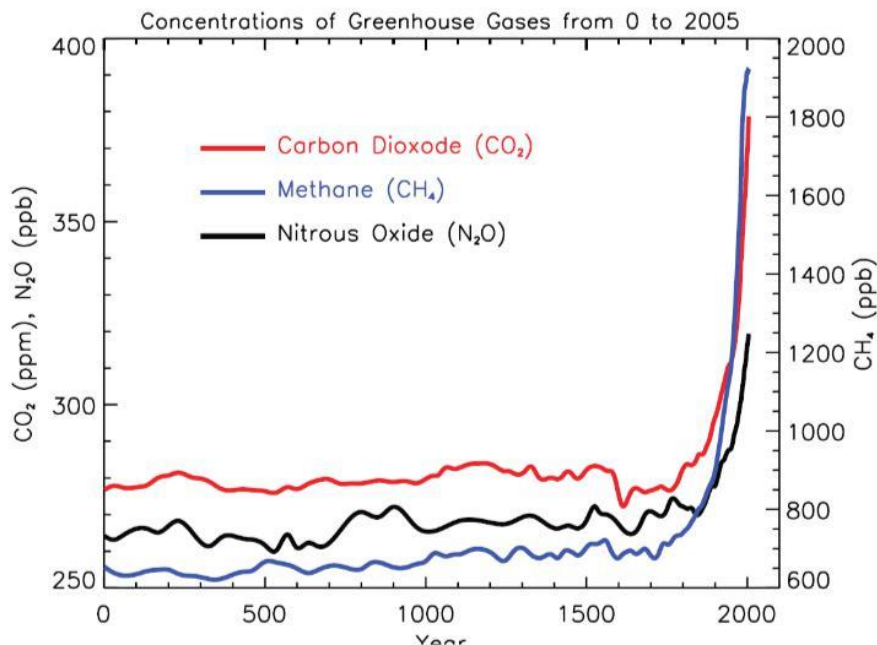


Figure 8: Trend of greenhouse gases in the atmosphere

Source: <http://ibabaeian.persianguig.com/image/Questions/GHGs-timeSeries.jpg>

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Similarly, Industrialization is adding 25% of the chlorofluorocarbon to the aerosol of the atmosphere. Consequently, global temperature increase is by about 1.5<sup>0</sup> F since 1880. The time taken for atmospheric carbon dioxide to adjust to changes in sources to sinks is 20-50 years. It is rising at about 0.5 per cent annually. Doubling of concentration of CO<sub>2</sub> over re-industrial level is used as an index for estimating the changes in climate in climatic models.

### **Ozone Hole**

Chlorofluorocarbons (CFCs) are products of human activity. Ozone occurs in the stratosphere where ultra-violet rays convert oxygen into ozone. Thus, ultra violet rays do not reach the earth's surface. The CFCs which drift into the stratosphere destroy the ozone. Large depletion of ozone occurs over Antarctica. The depletion of ozone concentration in the stratosphere is called the ozone hole. Ozone hole is created by chemical reaction. In fact ozone is O<sub>3</sub> but when O<sub>3</sub> breaking gases reaches to the layer, O<sub>3</sub> is converted to O<sub>2</sub>. O<sub>2</sub> is not able to absorb the ultraviolet rays. This condition is known as ozone hole. This allows the ultra violet rays to pass through the troposphere.

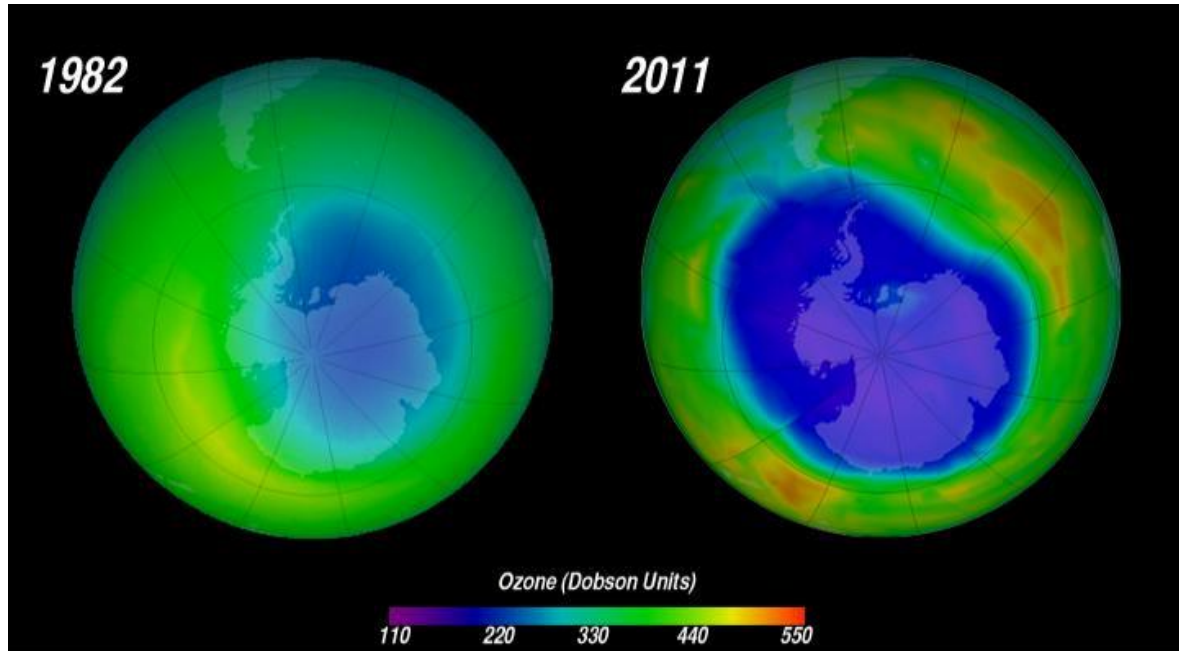


Figure 9: Intensifying ozone hole over the time

Source: <http://theutscmessenger.com/wp/wp-content/uploads/2011/10/Ozone.png>

International efforts have been initiated for reducing the emission of GHGs into the atmosphere. The most important one is the Kyoto protocol proclaimed in 1997. This protocol

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went into effect in 2005, ratified by 141 nations. Kyoto protocol bounds 35 industrialized countries to reduce their emissions by the year 2012 to 5% less than the levels prevalent in the year 1990. The increasing trend in the concentration of GHGs in the atmosphere may, in the long run, warm up the earth. Once the global warming sets in, it will be difficult to reverse it.

The effect of global warming may not be uniform everywhere. Nevertheless, the adverse effect due to global warming will adversely affect the life supporting system. Rise in the sea level due to melting of glaciers and ice-caps and thermal expansion of the sea may inundate large parts of the coastal area and islands, leading to social problems. This is another cause for serious concern for the world community.

Efforts have already been initiated to control the emission of GHGs and to arrest the trend towards global warming. Let us hope the world community responds to this challenge and adopts a lifestyle that leaves behind a liveable world for the generations to come.

One of the major concerns of the world today is global warming. Let us look at how much the planet has warmed up from the temperature records. Temperature data are available from the middle of the 19th century mostly for Western Europe. The reference period for this study is 1961-90. The temperature anomalies for the earlier and later periods are estimated from the average temperature for the period 1961-90.

The annual average near-surface air temperature of the world is approximately 14°C. The time series show anomalies of annual near surface temperature over land from 1856-2000, relative to the period 1961-90 as normal for the globe. An increasing trend in temperature was discernible in the 20th century. The greatest warming of the 20th century was during the two periods, 1901-44 and 1977-99. Over each of these two periods, global temperatures rose by about 0.4°C. In between, there was a slight cooling, which was more marked in the Northern Hemisphere.

The globally averaged annual mean temperature at the end of the 20th century was about 0.6°C above that recorded at the end of the 19th century. The seven warmest years during the 1856-2000 were recorded in the last decade. The year 1998 was the warmest year, probably

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not only for the 20th century but also for the whole millennium. The following collage related to the greenhouse gases and global warming tell a lot about the reality we are facing every day. With the passage of everyday, this situation is getting aggravated. We do about all almost every day in our newspaper. Now the time has come not to talk about but to act upon to confront and check the problem, otherwise it would be too late.

### **Conclusions**

The global warming is one of the most serious concern of humanity. Though the global warming and global cooling has been observed several time in the geological history. Previous such variations in global temperature were caused by natural factors. But the global warming we are observing today is induced by human activities. It is reflected in extinction

Writeof several an explanatory species and evolution of new species. Its impacts. can be seen on health of every living organisms on earth, on water resources, natural disaster, oxygen depletion, increase of carbon dioxide, acidification of oceans. The only remedy lays in the hands and action of human beings. They are not only unlawful for themselves but for whole of the living world existing on the earth.