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Sudan University of Science and Technology

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A Review of Climate Changes Due

to The Global Warming

أستعراض أدبيات تغير المناخ نتيجة للإحتباس الحراري

**A thesis submitted to the Sudan University of Science
and Technology in fulfillment of MSC in General Physics**

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Dedication

*To all whom I love and respect. My family and
friend*

*To all those who supported, participated, and advised
me through this research*

Acknowledgment

*I thank God for enabling me to complete this work
& sincerely thank*

Dr. Sawsan Ahmed Elhoury Ahmed

The supervisor, for her continuous help,

Supervision & guidance

I greatly indebted to all, especially to my mother.

*Finally I would like to thank everyone who has
participated in completion of this research.*

Abstract

In this research we studied the global warming by knowing the definition, and the causes. This research covers the Earth's atmosphere in details and the gases in each layer. Also the physical properties (pressure, thickness, temperature, speed of sound, density, mass), optical properties (scattering, absorption, emission, refractive index). Other aspects such as the Industrial Revolution and its role in the increase of greenhouse gases, the study covers United States of America, and China; as known there are the largest countries causing pollution due to heavy industry (ships, jets, cars, etc....). The study handled greenhouse gases and how it causes the global warming, the thing that made air pollution that cause climate changes. Finally, conclusion and recommendations were presented.

المستخلص

في هذا البحث قمنا بدراسة ظاهرة الاحتباس الحراري من خلال معرفة التعريف، والأسباب. ويشمل هذا البحث الغلاف الجوي للأرض بالتفاصيل والغازات في كل طبقة. أيضا الخصائص الفيزيائية (الضغط، وسمك، ودرجة الحرارة، وسرعة الصوت والكثافة والكتلة)، الخصائص البصرية (التشتت، الامتصاص، الانبعاث، معامل الانكسار). ودراسة جوانب أخرى مثل الثورة الصناعية ودورها في زيادة غازات الاحتباس الحراري، ودراسة تغطي الولايات المتحدة الأمريكية، والصين؛ كما هو معروف أنهما من أكبر الدول الملوثة بسبب الصناعات الثقيلة (السفن والطائرات، السيارات، الخ....) وتناولت دراسة الغازات المسببة للاحتباس الحراري وكيف تسبب ظاهرة الاحتباس الحراري، الأمر الذي رفع من تلوث الهواء التي تسبب التغيرات المناخية. وأخيرا، الاستنتاج وقدمت توصيات.

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Chapter One

Global Warming

1.1 Introduction

Global warming or climate change is an increase in surface temperature medium in the world with the increasing amount of carbon dioxide, methane and some other gases in the atmosphere. These gases known as greenhouse gases because they contribute to the Earth's atmosphere heating surface, a phenomenon known as global warming. Observed increase in average air temperature since the mid-twentieth century, with its continued rising, with increased surface temperature of the Earth's temperature by 0.74 ± 0.18 °F (1.33 ± 0.32 ° F) over the past century. The Intergovernmental Panel on Climate Change concluded that greenhouse gases resulting from human activities are responsible for most of the temperature rise observed since the mid-twentieth century, while the natural phenomena such as solar variation and volcanoes have a small warming effect since ages by the industry until 1950 and the impact of small cooled after that.

Temperature today is nearly double the rate before the 200-year-old. The causes of global warming are different; some scientists say that pollution is the main cause, while others say that it has changed in nature. There are several theories as to why this increase. Expected to increase the degree of the world's surface temperature by 1.4 ° to 5.8 ° Celsius from 1990 to 2100, the rate of the surface of the world's degree is now 0.6 ° Celsius [5,6].

1.2 Research Problem

Despite a scientific consensus on the subject, some people don't think global warming is happening at all. There are several reasons for this:

- They don't think the data show a measurable upward trend in global temperatures, either because we don't have enough long-term historical climate data or because the data we do have isn't clear enough.
- A few scientists think that data is being interpreted incorrectly by people who are already worried about global warming. That is, these people are looking for evidence of global warming in the statistics, instead of looking at the evidence objectively and trying to figure out what it means.

- Some argue any increase in global temperatures we are seeing could be a natural climate shift, or it could be due to other factors than greenhouse gases.

Most scientists recognize that global warming does seem to be happening, but a few don't believe that it is anything to be worried about. These scientists say that the Earth is more resistant to climate changes on this scale than we think. Plants and animals will adapt to subtle shifts in weather patterns, and it is unlikely anything catastrophic will happen as a result of global warming. Slightly longer growing seasons, changes in precipitation levels and stronger weather, in their opinion, are not generally disastrous. They also argue that the economic damage caused by cutting down on the emission of greenhouse gases will be far more damaging to humans than any of the effects of global warming.

1.3 Literature Review

1.3.1 Climate change in cities due to global warming and urban effects

Mark P. McCarthy, Martin J. Best,

Abstract

Urbanization is estimated to result in 6 billion urban dwellers by 2050. Cities will be exposed to climate change from greenhouse gas induced radioactive forcing, and localized effects from urbanization such as the urban heat island. An urban land-surface model has been included in the HadAM3 Global Climate Model. It shows that regions of high population growth coincide with regions of high urban heat island potential, most notably in the Middle East, the Indian sub-continent, and East Africa. Climate change has the capacity to modify the climatic potential for urban heat islands, with increases of 30% in some locations, but a global average reduction of 6%. Warming and extreme heat events due to urbanization and increased energy consumption are simulated to be as large as the impact of doubled CO₂ in some regions, and climate change increases the disparity in extreme hot nights between rural and urban areas [1].

1.3.2 Impact of regional climate change on human health

Patz, Jonathan A; Campbell

Lendrum , Diarmid; Holloway, Tracey; Foley,Jonathan A.

Abstract

The World Health Organization estimates that the warming and precipitation trends due to anthropogenic climate change of the past 30years already claim

over 150,000 lives annually. Many prevalent human diseases are linked to climate fluctuations, from cardiovascular mortality and respiratory illnesses due to heat waves, to altered transmission of infectious diseases and malnutrition from crop failures. Uncertainty remains in attributing the expansion or resurgence of diseases to climate change, owing to lack of long-term, high-quality data sets as well as the large influence of socio-economic factors and changes in immunity and drug resistance. Here we review the growing evidence that climate-health relationships pose increasing health risks under future projections of climate change and that the warming trend over recent decades has already contributed to increased morbidity and mortality in many regions of the world. Potentially vulnerable regions include the temperate latitudes, which are projected to warm disproportionately, the regions around the Pacific, and Indian oceans that are currently subjected to large rainfall variability due to the El Niño/Southern Oscillation sub-Saharan Africa and sprawling cities where the urban heat island effect could intensify extreme climatic events [2].

1.3.3 Earth's Energy Imbalance: Confirmation and Implications **James Hansen,**

Abstract

Our climate model, driven mainly by increasing human-made greenhouse gases and aerosols, among other forcing, calculates that Earth is now absorbing 0.85 ± 0.15 watts per square meter more energy from the Sun than it is emitting to space. This imbalance is confirmed by precise measurements of increasing ocean heat content over the past 10 years. Implications include (i) the expectation of additional global warming of about 0.6°C without further change of atmospheric composition; (ii) the confirmation of the climate system's lag in responding to forcings, implying the need for anticipatory actions to avoid any specified level of climate change; and (iii) the likelihood of acceleration of ice sheet disintegration and sea level rise [3].

1.3.4 Shifts in plant dominance control carbon-cycle responses to experimental warming and widespread drought **John Harte, Scott Saleska and Tiffany Shih-Published**

Abstract

Global climate change is predicted to increase the intensity and frequency of future drought, which in turn may be expected to induce a range of biogeochemical climate feedbacks. A combination of model simulations and observational studies of a recent wide-scale drought, suggested that the drought induced substantial terrestrial ecosystem carbon loss, but

hypothesized mechanisms could not be evaluated via comparison to a control. Here, we investigated carbon-cycle responses to climate changes by combining results from a controlled 15-year ecosystem warming experiment in montane grassland with observational data from before and during the recent drought. We found that both experimental warming and real-world drought induced substantial soil carbon loss in our study system, and that the same mechanism, a drying-induced shift in plant species composition and an associated decline in community productivity, provides a common explanation for these declines in soil carbon [4].

1.3 Objectives of the Study

- Knowledge of the problem of global warming and the stages built and shaped by the reasons that led him.
- Analysis of the search results and the extent of awareness of human danger of global warming.
- Find the latest developments.
- Raise public awareness members of the community to reduce the risk of emissions and take measures that will reduce the risk of global warming and preservation of the environment.
- Compared to the dangers resulting from global warming in terms of damage is to the air, water, living organisms.

1.4 Presentation of the thesis

In chapter presents an introduction of global warming, the research problem, literature review, and objectives of this research. In chapter two the atmosphere of earth and their physical properties Evolution of Earth's atmosphere. In chapter three presents industrial revolution, especially in unite state and china. Chapter four presents the green house gas effective, and Pollutants, especially air pollution. Chapter five about Conclusion and Recommendation.

Chapter Two Atmosphere of Earth

2.1 Introduction

Earth's atmosphere consists of a number of layers, summarized in the diagram above which explains what the layers are, that differ in properties such as composition, temperature and pressure. The lowest layer is the troposphere, which extends from the surface to the bottom of the stratosphere. Three quarters of the atmosphere's mass resides within the troposphere, and is the layer within which the Earth's weather develops. The depth of this layer varies between 17 km at the equator to 7 km at the poles. The stratosphere, extending from the top of the troposphere to the bottom of the mesosphere, contains the ozone layer. The ozone layer ranges in altitude between 15 and 35 km, and is where most of the ultraviolet radiation from the Sun is absorbed. The top of the mesosphere, ranges from 50 to 85 km, and is the layer wherein most meteors burn up. The thermosphere extends from 85 km to the base of the exosphere at 690 km and contains the ionosphere, a region where the atmosphere is ionized by incoming solar radiation. The ionosphere increases in thickness and moves closer to the Earth during daylight and rises at night allowing certain frequencies of radio communication a greater range. The Kármán line, located within the thermosphere at an altitude of 100 km, is commonly used to define the boundary between Earth's atmosphere and outer space. The exosphere begins variously from about 690 to 1,000 km above the surface, where it interacts with the planet's magnetosphere, to space. Each of the layers has a different lapse rate, defining the rate of change in temperature with height [5].

2.2 Mean atmospheric water vapor

The three major constituents of air, and therefore of Earth's atmosphere, are nitrogen, oxygen, and argon. Water vapor accounts for roughly 0.25% of the atmosphere by mass. The concentration of water vapor (a greenhouse gas) varies significantly from around 10 ppm by volume in the coldest portions of the atmosphere to as much as 5% by volume in hot, humid air masses, and concentrations of other atmospheric gases are typically quoted in terms of dry air (without water vapor). The remaining gases are often referred to as trace gases, among which are the greenhouse gases, principally carbon dioxide, methane, nitrous oxide, and ozone. Filtered air includes trace amounts of many other chemical compounds. Many substances of natural origin may be present in locally and seasonally variable small amounts as aerosols in an unfiltered air sample, including dust of mineral and organic composition,

pollen and spores, sea spray, and volcanic ash. Various industrial pollutants also may be present as gases or aerosols, such as chlorine (elemental or in compounds), fluorine compounds and elemental mercury vapor. Sulfur compounds such as hydrogen sulfide and sulfur dioxide (SO₂) may be derived from natural sources or from industrial air pollution [8].

2.3 Structure of the atmosphere

2.3.1 Principal layers

In general, air pressure and density decrease with altitude in the atmosphere. However, temperature has a more complicated profile with altitude, and may remain relatively constant or even increase with altitude in some regions (see the temperature section, below). Because the general pattern of the temperature/altitude profile is constant and measurable by means of instrumented balloon soundings, the temperature behavior provides a useful metric to distinguish atmospheric layers. In this way, Earth's atmosphere can be divided (called atmospheric stratification) into five main layers. Excluding the exosphere, Earth has four primary layers, which are the troposphere, stratosphere, mesosphere, and thermosphere. From highest to lowest, the five main layers are

- Exosphere: 700 to 10,000 km (440 to 6,200 miles)
- Thermosphere: 80 to 700 km (50 to 440 miles)
- Mesosphere: 50 to 80 km (31 to 50 miles)
- Stratosphere: 12 to 50 km (7 to 31 miles)
- Troposphere: 0 to 12 km (0 to 7 miles) [11]

2.3.1.1 Exosphere

The exosphere is the outermost layer of Earth's atmosphere (i.e. the upper limit of the atmosphere). It extends from the exobase, which is located at the top of the thermosphere at an altitude of about 700 km above sea level, to about 10,000 km (6,200 mi; 33,000,000 ft) where it merges into the solar wind.

This layer is mainly composed of extremely low densities of hydrogen, helium and several heavier molecules including nitrogen, oxygen and carbon dioxide closer to the exobase. The atoms and molecules are so far apart that they can travel hundreds of kilometers without colliding with one another. Thus, the exosphere no longer behaves like a gas, and the particles constantly escape into space. These free-moving particles follow ballistic trajectories and may migrate in and out of the magnetosphere or the solar wind.

The exosphere is located too far above Earth for any meteorological phenomena to be possible. However, the aurora borealis and aurora Australia sometimes occur in the lower part of the exosphere, where they overlap into the thermosphere. The exosphere contains most of the satellites orbiting Earth.

2.3.1.2 Thermosphere

The thermosphere is the second-highest layer of Earth's atmosphere. It extends from the mesopause (which separates it from the mesosphere) at an altitude of about 80 km (50 mi; 260,000 ft) up to the thermopause at an altitude range of 500–1000 km (310–620 mi; 1,600,000–3,300,000 ft). The height of the thermopause varies considerably due to changes in solar activity.^[8] Because the thermopause lies at the lower boundary of the exosphere, it is also referred to as the exobase. The lower part of the thermosphere, from 80 to 550 kilometers (50 to 342 mi) above Earth's surface, contains the ionosphere.

The temperature of the thermosphere gradually increases with height. Unlike the stratosphere beneath it, wherein a temperature inversion is due to the absorption of radiation by ozone, the inversion in the thermosphere occurs due to the extremely low density of its molecules. The temperature of this layer can rise as high as 1500 °C (2700 °F), though the gas molecules are so far apart that its temperature in the usual sense is not very meaningful. The air is so rarefied that an individual molecule (of oxygen, for example) travels an average of 1 kilometer (0.62 mi; 3300 ft) between collisions with other molecules. Although the thermosphere has a high proportion of molecules with high energy, it would not feel hot to a human in direct contact, because its density is too low to conduct a significant amount of energy to or from the skin.

This layer is completely cloudless and free of water vapor. However non-hydro meteorological phenomena such as the aurora borealis and aurora Australia are occasionally seen in the thermosphere. The International Space Station orbits in this layer, between 350 and 420 km (220 and 260 mi).

2.3.1.3 Mesosphere

The mesosphere is the third highest layer of Earth's atmosphere, occupying the region above the stratosphere and below the thermosphere. It extends from the stratopause at an altitude of about 50 km (31 mi; 160,000 ft) to the mesopause at 80–85 km (50–53 mi; 260,000–280,000 ft) above sea level.

Temperatures drop with increasing altitude to the mesopause that marks the top of this middle layer of the atmosphere. It is the coldest place on Earth and has an average temperature around –85 °C (–120 °F; 190 K). Just below the

mesopause, the air is so cold that even the very scarce water vapor at this altitude can be sublimated into polar-mesospheric noctilucent clouds. These are the highest clouds in the atmosphere and may be visible to the naked eye if sunlight reflects off them about an hour or two after sunset or a similar length of time before sunrise. They are most readily visible when the Sun is around 4 to 16 degrees below the horizon. A type of lightning referred to as either sprites or ELVES, occasionally form far above tropospheric thunderclouds. The mesosphere is also the layer where most meteors burn up upon atmospheric entrance. It is too high above Earth to be accessible to jet-powered aircraft and balloons, and too low to permit orbital spacecraft. The mesosphere is mainly accessed by sounding rockets and rocket-powered aircraft.

2.3.1.4 Stratosphere

The stratosphere is the second-lowest layer of Earth's atmosphere. It lies above the troposphere and is separated from it by the tropopause. This layer extends from the top of the troposphere at roughly 12 km (7.5 mi; 39,000 ft) above Earth's surface to the stratopause at an altitude of about 50 to 55 km (31 to 34 mi; 164,000 to 180,000 ft). The atmospheric pressure at the top of the stratosphere is roughly 1/1000 the pressure at sea level. It contains the ozone layer, which is the part of Earth's atmosphere that contains relatively high concentrations of that gas. The stratosphere defines a layer in which temperatures rise with increasing altitude. This rise in temperature is caused by the absorption of ultraviolet radiation (UV) radiation from the Sun by the ozone layer, which restricts turbulence and mixing. Although the temperature may be $-60\text{ }^{\circ}\text{C}$ ($-76\text{ }^{\circ}\text{F}$; 210 K) at the tropopause, the top of the stratosphere is much warmer, and may be near $0\text{ }^{\circ}\text{C}$. The stratospheric temperature profile creates very stable atmospheric conditions, so the stratosphere lacks the weather-producing air turbulence that is so prevalent in the troposphere. Consequently, the stratosphere is almost completely free of clouds and other forms of weather. However, polar stratospheric or nacreous clouds are occasionally seen in the lower part of this layer of the atmosphere where the air is coldest. This is the highest layer that can be accessed by jet-powered aircraft.

2.3.1.5 Troposphere

The troposphere is the lowest layer of Earth's atmosphere. It extends from Earth's surface to an average height of about 12 km, although this altitude actually varies from about 9 km (30,000 ft) at the poles to 17 km (56,000 ft) at the equator, with some variation due to weather. The troposphere is bounded above by the tropopause, a boundary marked in most places by a temperature

inversion (i.e. a layer of relatively warm air above a colder one), and in others by a zone which is isothermal with height.

Although variations do occur, the temperature usually declines with increasing altitude in the troposphere because the troposphere is mostly heated through energy transfer from the surface. Thus, the lowest part of the troposphere (i.e. Earth's surface) is typically the warmest section of the troposphere. This promotes vertical mixing (hence the origin of its name in the Greek word *τρόπος*, *tropos*, meaning "turn"). The troposphere contains roughly 80% of the mass of Earth's atmosphere.^[16] The troposphere is denser than all its overlying atmospheric layers because a larger atmospheric weight sits on top of the troposphere and causes it to be most severely compressed. Fifty percent of the total mass of the atmosphere is located in the lower 5.6 km (18,000 ft) of the troposphere.

Nearly all atmospheric water vapor or moisture is found in the troposphere, so it is the layer where most of Earth's weather takes place. It has basically all the weather-associated cloud genus types generated by active wind circulation, although very tall cumulonimbus thunder clouds can penetrate the tropopause from below and rise into the lower part of the stratosphere. Most conventional aviation activity takes place in the troposphere, and it is the only layer that can be accessed by propeller-driven aircraft. Space Shuttle *Endeavour* orbiting in the thermosphere. Because of the angle of the photo, it appears to straddle the stratosphere and mesosphere that actually lie more than 250 km below. The orange layer is the troposphere, which gives way to the whitish stratosphere and then the blue mesosphere[12,13,14].

2.3.1.6 Other layers

Within the five principal layers that are largely determined by temperature, several secondary layers may be distinguished by other properties:

- **The ozone layer** is contained within the stratosphere. In this layer ozone concentrations are about 2 to 8 parts per million, which is much higher than in the lower atmosphere but still very small compared to the main components of the atmosphere. It is mainly located in the lower portion of the stratosphere from about 15–35 km (9.3–21.7 mi; 49,000–115,000 ft), though the thickness varies seasonally and geographically. About 90% of the ozone in Earth's atmosphere is contained in the stratosphere.
- **The ionosphere** is a region of the atmosphere that is ionized by solar radiation. It is responsible for auroras. During daytime hours, it stretches from 50 to 1,000 km (31 to 621 mi; 160,000 to 3,280,000 ft) and includes the mesosphere, thermosphere, and parts of the exosphere.

However, ionization in the mesosphere largely ceases during the night, so auroras are normally seen only in the thermosphere and lower exosphere. The ionosphere forms the inner edge of the magnetosphere. It has practical importance because it influences, for example, radio propagation on Earth.

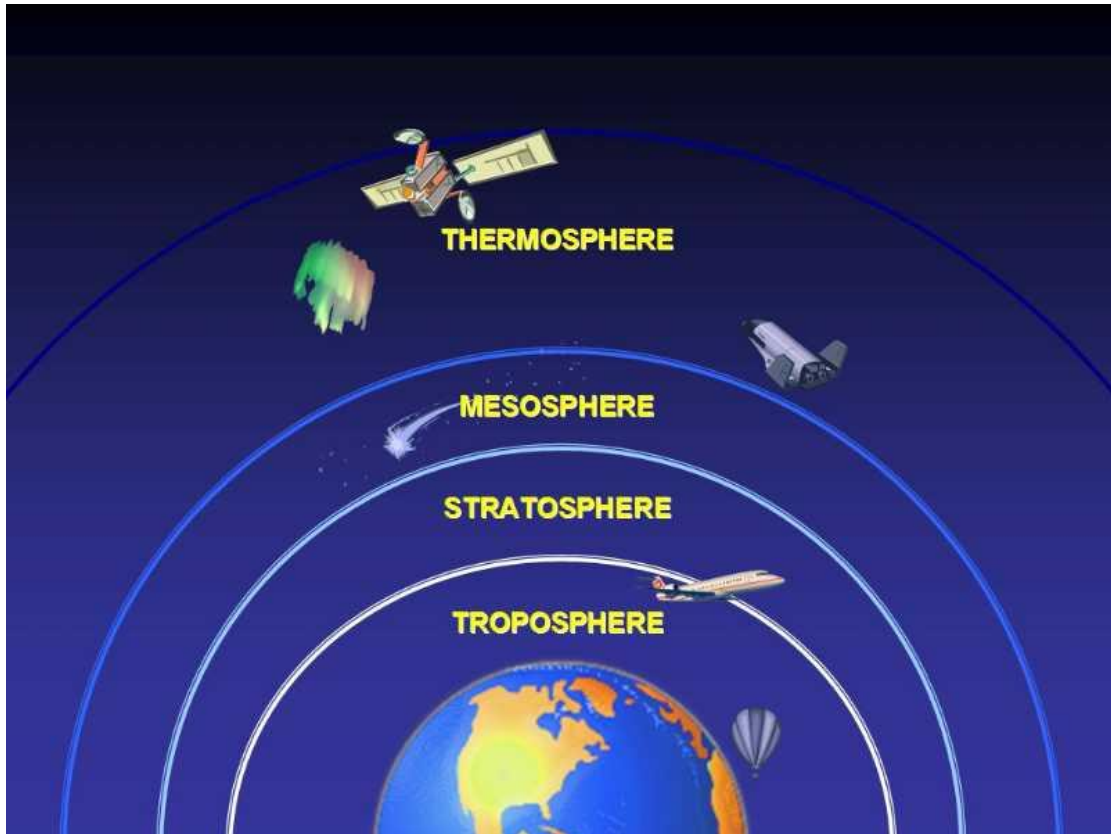
- **The homosphere and heterosphere** are defined by whether the atmospheric gases are well mixed. The surface-based homosphere includes the troposphere, stratosphere, mesosphere, and the lowest part of the thermosphere, where the chemical composition of the atmosphere does not depend on molecular weight because the gases are mixed by turbulence. This relatively homogeneous layer ends at the *turbopause* found at about 100 km (62 mi; 330,000 ft), which places it about 20 km (12 mi; 66,000 ft) above the mesopause[15].

Above this altitude lies the heterosphere, which includes the exosphere and most of the thermosphere. Here, the chemical composition varies with altitude. This is because the distance that particles can move without colliding with one another is large compared with the size of motions that cause mixing. This allows the gases to stratify by molecular weight, with the heavier ones, such as oxygen and nitrogen, present only near the bottom of the heterosphere. The upper part of the heterosphere is composed almost completely of hydrogen, the lightest element.

- **The planetary boundary layer** is the part of the troposphere that is closest to Earth's surface and is directly affected by it, mainly through turbulent diffusion. During the day the planetary boundary layer usually is well-mixed, whereas at night it becomes stably stratified with weak or intermittent mixing. The depth of the planetary boundary layer ranges from as little as about 100 meters on clear, calm nights to 3000 m or more during the afternoon in dry regions.

The average temperature of the atmosphere at Earth's surface is 14 °C (57 °F; 287 K) or 15 °C (59 °F; 288 K). so its radiation peaks near 10,000 nm, and is much too long to be visible to humans. Because of its temperature, the atmosphere emits infrared radiation. For example, on clear nights Earth's surface cools down faster than on cloudy nights. This is because clouds (H₂O) are strong absorbers and emitters of infrared radiation. This is also why it becomes colder at night at higher elevations.

The greenhouse effect is directly related to this absorption and emission effect. Some gases in the atmosphere absorb and emit infrared radiation, but do not interact with sunlight in the visible spectrum. Common examples of these are CO₂ and H₂O [16].



2.4 Physical properties

2.4.1 Pressure and thickness

Atmospheric pressure:

The average atmospheric pressure at sea level is defined by the International Standard Atmosphere as 101325 Pascal's (760.00 Torre; 14.6959 psi; 760.00 mmHg). This is sometimes referred to as a unit of standard atmospheres (atm). Total atmospheric mass is 5.1480×10^{18} kg (1.135×10^{19} lb), about 2.5% less than would be inferred from the average sea level pressure and Earth's area of 51007.2 mega hectares, this portion being displaced by Earth's mountainous terrain. Atmospheric pressure is the total weight of the air above unit area at the point where the pressure is measured. Thus air pressure varies with location and weather.

If the entire mass of the atmosphere had a uniform density from sea level, it would terminate abruptly at an altitude of 8.50 km (27,900 ft). It actually decreases exponentially with altitude, dropping by half every 5.6 km (18,000 ft) or by a factor of $1/e$ every 7.64 km (25,100 ft), the average scale height of the atmosphere below 70 km (43 mi; 230,000 ft). However, the atmosphere is more accurately modeled with a customized equation for each layer that takes gradients of temperature, molecular composition, solar radiation and gravity into account.

In summary, the mass of Earth's atmosphere is distributed approximately as follows:

- 50% is below 5.6 km (18,000 ft).
- 90% is below 16 km (52,000 ft).
- 99.99997% is below 100 km (62 mi; 330,000 ft), the Karman line. By international convention, this marks the beginning of space where human travelers are considered astronauts.

By comparison, the summit of Mt. Everest is at 8,848 m (29,029 ft); commercial airliners typically cruise between 10 km (33,000 ft) and 13 km (43,000 ft) where the thinner air improves fuel economy; weather balloons reach 30.4 km (100,000 ft) and above; and the highest X-15 flight in 1963 reached 108.0 km (354,300 ft).

Even above the Karman line, significant atmospheric effects such as auroras still occur. Meteors begin to glow in this region, though the larger ones may not burn up until they penetrate more deeply. The various layers of Earth's ionosphere, important to HF radio propagation, begin below 100 km and extend beyond 500 km. By comparison, the International Space Station and Space Shuttle typically orbit at 350–400 km, within the F-layer of the ionosphere where they encounter enough atmospheric drag to require reboots every few months. Depending on solar activity, satellites can experience noticeable atmospheric drag at altitudes as high as 700–800 km.

2.4.2 Temperature and speed of sound

Atmospheric temperature and Speed of sound

The division of the atmosphere into layers mostly by reference to temperature is discussed above. Temperature decreases with altitude starting at sea level, but variations in this trend begin above 11 km, where the temperature stabilizes through a large vertical distance through the rest of the troposphere. In the stratosphere, starting above about 20 km, the temperature increases with height, due to heating within the ozone layer caused by capture of significant ultraviolet radiation from the Sun by the deoxygenate and ozone gas in this region. Still another region of increasing temperature with altitude occurs at very high altitudes, in the aptly-named thermosphere above 90 km.

Because in an ideal gas of constant composition the speed of sound depends only on temperature and not on the gas pressure or density, the speed of sound in the atmosphere with altitude takes on the form of the complicated temperature profile (see illustration to the right), and does not mirror altitudinal changes in density or pressure.

2.4.3 Density and mass

Density of air

The density of air at sea level is about 1.2 kg/m³ (1.2 g/L, 0.0012 g/cm³). Density is not measured directly but is calculated from measurements of temperature, pressure and humidity using the equation of state for air (a form of the ideal gas law). Atmospheric density decreases as the altitude increases. This variation can be approximately modeled using the barometric formula. More sophisticated models are used to predict orbital decay of satellites.

The average mass of the atmosphere is about 5 quadrillion (5×10^{15}) tones or 1/1,200,000 the mass of Earth. According to the American National Center for Atmospheric Research, "The total mean mass of the atmosphere is 5.1480×10^{18} kg with an annual range due to water vapor of 1.2 or 1.5×10^{15} kg, depending on whether surface pressure or water vapor data are used; somewhat smaller than the previous estimate. The mean mass of water vapor is estimated as 1.27×10^{16} kg and the dry air mass as $5.1352 \pm 0.0003 \times 10^{18}$ kg."

2.5 Optical properties

Solar radiation (or sunlight) is the energy Earth receives from the Sun. Earth also emits radiation back into space, but at longer wavelengths that we cannot see. Part of the incoming and emitted radiation is absorbed or reflected by the atmosphere.

2.5.1 Scattering

When light passes through Earth's atmosphere, photons interact with it through *scattering*. If the light does not interact with the atmosphere, it is called direct radiation and is what you see if you were to look directly at the Sun. Indirect radiation is light that has been scattered in the atmosphere. For example, on an overcast day when you cannot see your shadow there is no direct radiation reaching you, it has all been scattered. As another example, due to a phenomenon called Rayleigh scattering, shorter (blue) wavelengths scatter more easily than longer (red) wavelengths. This is why the sky looks blue; you are seeing scattered blue light. This is also why sunsets are red. Because the Sun is close to the horizon, the Sun's rays pass through more atmosphere than normal to reach your eye. Much of the blue light has been scattered out, leaving the red light in a sunset.

2.5.2 Absorption

Absorption (electromagnetic radiation)

Different molecules absorb different wavelengths of radiation. For example, O₂ and O₃ absorb almost all wavelengths shorter than 300 nanometers. Water (H₂O) absorbs many wavelengths above 700 nm. When a molecule absorbs a photon, it increases the energy of the molecule. This heats the atmosphere, but the atmosphere also cools by emitting radiation, as discussed below.

The combined absorption spectra of the gases in the atmosphere leave "windows" of low opacity, allowing the transmission of only certain bands of light. The optical window runs from around 300 nm (ultraviolet-C) up into the range humans can see, the visible spectrum (commonly called light), at roughly 400–700 nm and continues to the infrared to around 1100 nm. There are also infrared and radio windows that transmit some infrared and radio waves at longer wavelengths. For example, the radio window runs from about one centimeter to about eleven-meter waves.

2.5.3 Emission

Emission (electromagnetic radiation)

Emission is the opposite of absorption; it is when an object emits radiation. Objects tend to emit amounts and wavelengths of radiation depending on their "black body" emission curves, therefore hotter objects tend to emit more radiation, with shorter wavelengths. Colder objects emit less radiation, with longer wavelengths. For example, the Sun is approximately 6,000 K (5,730 °C; 10,340 °F), its radiation peaks near 500 nm, and is visible to the human eye. Earth is approximately 290 K (17 °C; 62 °F), so its radiation peaks near 10,000 nm, and is much too long to be visible to humans.

Because of its temperature, the atmosphere emits infrared radiation. For example, on clear nights Earth's surface cools down faster than on cloudy nights. This is because clouds (H₂O) are strong absorbers and emitters of infrared radiation. This is also why it becomes colder at night at higher elevations.

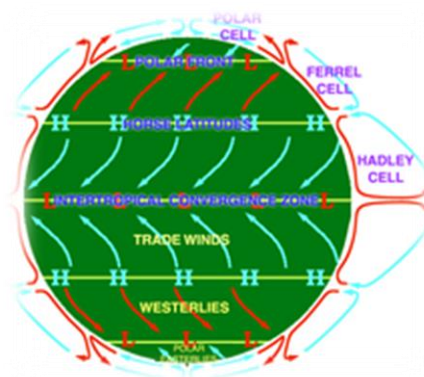
The greenhouse effect is directly related to this absorption and emission effect. Some gases in the atmosphere absorb and emit infrared radiation, but do not interact with sunlight in the visible spectrum. Common examples of these are CO₂ and H₂O.

2.5.4 Refractive index

The refractive index of air is close to, but just greater than 1. Systematic variations in refractive index can lead to the bending of light rays over long optical paths. One example is that, under some circumstances, observers onboard ships can see other vessels just over the horizon because light is refracted in the same direction as the curvature of Earth's surface. The refractive index of air depends on temperature, giving rise to refraction effects when the temperature gradient is large. An example of such effects is the mirage [17].

2.5.5 Circulation

Atmospheric circulation



An idealized view of three large circulation cells.

Atmospheric circulation is the large-scale movement of air through the troposphere, and the means (with ocean circulation) by which heat is distributed around Earth. The large-scale structure of the atmospheric circulation varies from year to year, but the basic structure remains fairly constant because it is determined by Earth's rotation rate and the difference in solar radiation between the equator and poles[9].

2.6 Evolution of Earth's atmosphere

2.6.1 Earliest atmosphere

The first atmosphere would have consisted of gases in the solar nebula, primarily hydrogen. In addition, there would probably have been simple hydrides such as those now found in the gas giants (Jupiter and Saturn), notably water vapor, methane and ammonia. As the solar nebula dissipated, these gases would have escaped, partly driven off by the solar wind.

2.6.2 Second atmosphere

Outgassing from volcanism, supplemented by gases produced during the late heavy bombardment of Earth by huge asteroids, produced the next atmosphere, consisting largely of nitrogen plus carbon dioxide and inert gases. A major part of carbon-dioxide emissions soon dissolved in water and built up carbonate sediments.

Researchers have found water-related sediments dating from as early as 3.8 billion years ago. About 3.4 billion years ago, nitrogen formed the major part of the then stable "second atmosphere". An influence of life has to be taken into account rather soon in the history of the atmosphere, because hints of early life-forms appear as early as 3.5 billion years ago. How Earth at that time maintained a climate warm enough for liquid water and life, if the early Sun put out 30% lower solar radiance than today, is a puzzle known as the "faint young Sun paradox".

The geological record however shows a continually relatively warm surface during the complete early temperature record of Earth - with the exception of one cold glacial phase about 2.4 billion years ago. In the late Archean eon an oxygen-containing atmosphere began to develop, apparently produced by photosynthesizing cyanobacteria (see Great Oxygenation Event), which have been found as stromatolite fossils from 2.7 billion years ago. The early basic carbon isotopic (isotope ratio proportions) very much approximates current conditions, suggesting that the fundamental features of the carbon cycle became established as early as 4 billion years ago.

Ancient sediments in the Republic of Gabon dating from between about 2,150 and 2,080 million years ago provide a record of Earth's dynamic oxygenation evolution. These fluctuations in oxygenation were likely driven by the Lomagundi carbon isotope excursion.

2.6.3 Third atmosphere

The constant re-arrangement of continents by plate tectonics influences the long-term evolution of the atmosphere by transferring carbon dioxide to and from large continental carbonate stores. Free oxygen did not exist in the atmosphere until about 2.4 billion years ago during the Great Oxygenation Event and its appearance is indicated by the end of the banded iron formations. Before this time, any oxygen produced by photosynthesis was consumed by oxidation of reduced materials, notably iron. Molecules of free oxygen did not start to accumulate in the atmosphere until the rate of production of oxygen began to exceed the availability of reducing materials. This point signifies a shift from a reducing atmosphere to an oxidizing

atmosphere. O₂ showed major variations until reaching a steady state of more than 15% by the end of the Precambrian. The following time span from 541 million years ago to the present day is the Phanerozoic eon, during the earliest period of which, the Cambrian, oxygen-requiring metazoan life forms began to appear.

The amount of oxygen in the atmosphere has fluctuated over the last 600 million years, reaching a peak of about 30% around 280 million years ago, significantly higher than today's 21%. Two main processes govern changes in the atmosphere: Plants use carbon dioxide from the atmosphere, releasing oxygen. Breakdown of pyrite and volcanic eruptions release sulfur into the atmosphere, which oxidizes and hence reduces the amount of oxygen in the atmosphere. However, volcanic eruptions also release carbon dioxide, which plants can convert to oxygen. The exact cause of the variation of the amount of oxygen in the atmosphere is not known. Periods with much oxygen in the atmosphere are associated with rapid development of animals. Today's atmosphere contains 21% oxygen, which is high enough for this rapid development of animals [18].

Chapter Three

Industrial Revolution

3.1 Introduction

Historical Background

The Industrial Revolution was the transition to new manufacturing processes in the period from about 1760 to sometime between 1820 and 1840. This transition included going from hand production methods to machines, new chemical manufacturing and iron production processes, improved efficiency of water power, the increasing use of steam power, the development of machine tools and the rise of the factory system. Textiles were the dominant industry of the Industrial Revolution in terms of employment, value of output and capital invested; the textile industry was also the first to use modern production methods. The Industrial Revolution began in Great Britain and most of the important technological innovations were British. The Industrial Revolution marks a major turning point in history; almost every aspect of daily life was influenced in some way. In particular, average income and population began to exhibit unprecedented sustained growth. Some economists say that the major impact of the Industrial Revolution was that the standard of living for the general population began to increase consistently for the first time in history, although others have said that it did not begin to meaningfully improve until the late 19th and 20th centuries. At approximately the same time the Industrial Revolution was occurring, Britain was undergoing an agricultural revolution, which also helped to improve living standards and provided surplus labor available for industry. Mechanized textile production spread from Great Britain to continental Europe in the early 19th century, with important centers of textiles, iron and coal emerging in Belgium, and later in France. Since then industrialization has spread throughout much of the world. The precise start and end of the Industrial Revolution is still debated among historians, as is the pace of economic and social changes. GDP per capita was broadly stable before the Industrial Revolution and the emergence of the modern capitalist economy, while the Industrial Revolution began an era of per-capita economic growth in capitalist economies. Economic historians are in agreement that the onset of the Industrial Revolution is the most important event in the history of humanity since the domestication of animals and plants. The First Industrial Revolution evolved into the Second Industrial Revolution in the transition years between 1840 and 1870, when technological and economic progress continued with the increasing adoption of steam transport (steam-powered railways, boats and ships), the large-scale manufacture of machine tools and the increasing use of machinery in steam-powered factories [20].

3.2 Industry in United State

The United States is the world's largest national economy in nominal terms and second largest according to purchasing power parity (PPP), representing 22% of nominal global GDP and 17% of gross wototal trade amounted to \$4.93T in 2012. Of the world's 500 largest companies, 128 are headquartered in the US.

The United States has one of the world's largest and most influential financial markets. The New York Stock Exchange is by far the world's largest stock exchange by market capitalization. Foreign investments made in the US total almost \$2.4 trillion, while American investments in foreign countries total over \$3.3 trillion. The economy of the U.S. leads in international ranking on venture capital and Global Research and Development funding. Consumer spending comprises 71% of the US economy in 2013. The United States has the largest consumer market in the world, with a household final consumption expenditure five times larger than Japan's. The labor market has attracted immigrants from all over the world and its net migration rate is among the highest in the world. The U.S. is one of the top-performing economies in studies such as the Ease of Doing Business Index, the Global Competitiveness Report, and others.

The US economy went through an economic downturn following the financial crisis of 2007–08, with output as late as 2013 still below potential according to the Congressional Budget Office. The economy, however, began to recover in the second half of 2009, and as of November 2015, unemployment had declined from a high of 10% to 5%.

In December 2014, public debt was slightly more than 100% of GDP. Domestic financial assets totaled \$131 trillion and domestic financial liabilities totaled \$106 trillion.

3.2.1 Arms industry

The arms industry, also known as the military industry or the arms trade, is a global business responsible for the manufacturing and sales of weapons and military technology and equipment. It consists of a commercial industry involved in the research and development, engineering, production, and servicing of military material, equipment, and facilities. Arms-producing companies, also referred to as defense contractors or as the military industry, produce arms mainly for the armed forces of states. Departments of government also operate in the arms industry, buying and selling weapons, munitions and other military items. Products include guns, artillery,

ammunition, missiles, military aircraft, military vehicles, ships, electronic systems, and more. The arms industry also provides other logistical and operational support.

Stockholm International Peace Research Institute (SIPRI) estimated in 2012 that 2012 military expenditures were roughly 1.8 trillion United States dollars.^[1] This represents a relative decline from 1990 when military expenditures made up 4% of world GDP. Part of the money goes to the procurement of military hardware and services from the military industry. The combined arms sales of the top 100 largest arms-producing companies amounted to an estimated \$395 billion in 2012 according to SIPRI. In 2004 over \$30 billion were spent in the international arms trade (a figure that excludes domestic sales of arms). According to SIPRI, the volume of international transfers of major weapons in 2010–14 was 16 per cent higher than in 2005–2009. The five biggest exporters in 2010–2014 were the United States, Russia, China, Germany and France, and the five biggest importers were India, Saudi Arabia, China, the United Arab Emirates (UAE) and Pakistan.

Many industrialized countries have a domestic arms-industry to supply their own military forces. Some countries also have a substantial legal or illegal domestic trade in weapons for use by its citizens. Illegal trade in small arms occurs in many countries and regions affected by political instability. The Small Arms Survey estimates that 875 million small arms circulate worldwide, produced by more than 1,000 companies from nearly 100 countries. Contracts to supply a given country's military are awarded by governments, making arms contracts of substantial political importance. The link between politics and the arms trade can result in the development of what U.S. President Dwight D. Eisenhower described as a military-industrial complex, where the armed forces, commerce, and politics become closely linked, similarly to the European defiance procurement. Various corporations, some publicly held, others private, bid for these contracts, which are often worth many billions of dollars. Sometimes, as with the contract for the international Joint Strike Fighter, a competitive tendering process takes place, with the decision made on the merits of the designs submitted by the companies involved. Other times, no bidding or competition takes place.

3.2.2 Iron and steel-making

Steel is an alloy of iron and other elements, primarily carbon, that is widely used in construction and other applications because of its high tensile strength and low cost. Steel's base metal is iron, which is able to take on two crystalline forms (allotropic forms), body centered cubic (BCC) and face centered cubic

(FCC), depending on its temperature. It is the interaction of those allotropes with the alloying elements, primarily carbon, that gives steel and cast iron their range of unique properties. In the body-centred cubic arrangement, there is an iron atom in the centre of each cube, and in the face-centred cubic, there is one at the center of each of the six faces of the cube. Carbon, other elements, and inclusions within iron act as hardening agents that prevent the movement of dislocations that otherwise occur in the crystal lattices of iron atoms.

The carbon in typical steel alloys may contribute up to 2.1% of its weight. Varying the amount of alloying elements, their presence in the steel either as solute elements, or as precipitated phases, retards the movement of those dislocations that make iron comparatively ductile and weak, and thus controls its qualities such as the hardness, ductility, and tensile strength of the resulting steel. Steel's strength compared to pure iron is only possible at the expense of iron's ductility, of which iron has an excess.

Steel was produced in bloomery furnaces for thousands of years, but its extensive use began after more efficient production methods were devised in the 17th century, with the production of blister steel and then crucible steel. With the invention of the Bessemer process in the mid-19th century, a new era of mass-produced steel began. This was followed by Siemens-Martin process and then Gilchrist-Thomas process that refined the quality of steel. With their introductions, mild steel replaced wrought iron.

Further refinements in the process, such as basic oxygen steelmaking (BOS), largely replaced earlier methods by further lowering the cost of production and increasing the quality of the product. Today, steel is one of the most common materials in the world, with more than 1.3 billion tons produced annually. It is a major component in buildings, infrastructure, tools, ships, automobiles, machines, appliances, and weapons. Modern steel is generally identified by various grades defined by assorted standards organizations [21].

3.3 Industry in China

Industry is 72.8% of China's gross domestic product (GDP) in 2005. Industry (including mining, manufacturing, construction, and power) contributed 46.8 percent of GDP in 2010 and occupied 27 percent of the workforce in 2007. As of 2015, the manufacturing industrial sectors contribute 40% of China's GDP. The manufacturing sector produced 44.1 percent of GDP in 2004 and accounted for 11.3 percent of total employment in 2006. China is the world's leading manufacturer of chemical fertilizers, cement, and steel. Prior to 1978,

most output was produced by state-owned enterprises. As a result of the economic reforms that followed, there was a significant increase in production by enterprises sponsored by local governments, especially townships and villages, and, increasingly, by private entrepreneurs and foreign investors, but by 1990 the state sector accounted for about 70 percent of output. By 2002 the share in gross industrial output by state-owned and state-holding industries had decreased with the state-run enterprises themselves accounting for 46 percent of China's industrial output. In November, 2012 the State Council of the People's Republic of China mandated a "social risk assessment" for all major industrial projects. This requirement followed mass public protests in some locations for planned projects or expansions.

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3.3.2 Iron and steel-making

Concomitant with automotive production and other steel-consuming industries, China has been rapidly increasing its steel production. Iron ore production kept pace with steel production in the early 1990s but was soon outpaced by imported iron ore and other metals in the early 2000s. Steel production, an estimated 140 million tons in 2000, rose to more than 420 million tons by 2007.

Before the first five-year plan (1953–57), China had only one major steel center— Anshan, in the northeast—and several minor ones. All these produced 1.93 million tons of pig iron and 1.35 million tons of steel in 1952. By 1995, China was producing 92,970 million tons of crude steel and 101,700 million tons of pig iron. China had one trillion tons of confirmed coal reserves and an estimated five trillion tons of coal reserves and 48.7 billion tons of iron ore in 2000. Anshan continues to be the hub of the industry, but other huge steel complexes have been constructed at Baotou, Benxi (about 50 km east of Anshan), Taiyuan, Wuhan, and Ma'an Shan (near Nanjing) [22].

3.3.3 Automobile

An example of an emerging heavy industry is automobile manufacture, which has soared during the reform period. In 1975 only 139,800 automobiles were produced annually, but by 1985 production had reached 443,377, then jumped to nearly 1.1 million by 1992 and increased fairly evenly each year up until 2001, when it reached 2.3 million. In 2002 production rose to nearly 3.3

million and then jumped again the next year to 4.4 million. Domestic sales have kept pace with production. After respectable annual increases in the mid- and late 1990s, sales soared in the early 2000s, reaching 3 million automobiles sold in 2003. With some governmental controls in place, sales dipped to 2.4 million sold in 2004. Sales automobiles and vans reached 13 million in 2010. So successful has China's automotive industry been that it began exporting car parts in 1999. China began to plan major moves into the automobile and components export business starting in 2005. A new Honda factory in Guangzhou was being built in 2004 solely for the export market and was expected to ship 30,000 passenger vehicles to Europe in 2005. By 2004, 12 major foreign automotive manufacturers had joint-venture plants in China. They produced a wide range of automobiles, minivans, sport utility vehicles, buses, and trucks. In 2003 China exported US\$4.7 billion worth of vehicles and components, an increase of 34.4 percent over 2002. By 2004 China had become the world's fourth largest automotive vehicle manufacturer [5].

Chapter Four Greenhouse Gas

4.1 Introduction

A **Greenhouse Gas** (sometimes abbreviated **GHG**) is a gas in an atmosphere that absorbs and emits radiation within the thermal infrared range. This process is the fundamental cause of the greenhouse effect. The primary greenhouse gases in Earth's atmosphere are water vapor, carbon dioxide, methane, nitrous oxide, and ozone. Without greenhouse gases, the average temperature of Earth's surface would be about $-18\text{ }^{\circ}\text{C}$ ($0\text{ }^{\circ}\text{F}$). rather than the present average of $15\text{ }^{\circ}\text{C}$ ($59\text{ }^{\circ}\text{F}$). In the Solar System, the atmospheres of Venus, Mars and Titan also contain gases that cause a greenhouse effect.

Human activities since the beginning of the Industrial Revolution (taken as the year 1750) have produced a 40% increase in the atmospheric concentration of carbon dioxide, from 280 ppm in 1750 to 400 ppm in 2015. This increase has occurred despite the uptake of a large portion of the emissions by various natural "sinks" involved in the carbon cycle. Anthropogenic carbon dioxide (CO_2) emissions (i.e. emissions produced by human activities) come from combustion of carbon-based fuels, principally coal, oil, and natural gas, along with deforestation, soil erosion and animal agriculture.

It has been estimated that if greenhouse gas emissions continue at the present rate, Earth's surface temperature could exceed historical values as early as 2047, with potentially harmful effects on ecosystems, biodiversity and the livelihoods of people worldwide. Recent estimates suggest that on the current emissions trajectory the Earth could pass a threshold of 2°C global warming, which the United Nations' IPCC designated as the upper limit for "dangerous" global warming, by 2036 [5,7].

4.2 Gases in Earth's atmosphere

4.2.1 Non-greenhouse gases

The major atmospheric constituents, nitrogen (N_2), oxygen (O_2) and argon (Ar), are not greenhouse gases because molecules containing two atoms of the same element such as N_2 and O_2 and monatomic molecules such as argon (Ar) have no net change in the distribution of their electrical charges when they vibrate and hence are almost totally unaffected by infrared radiation. Although molecules containing two atoms of different elements such as carbon monoxide (CO) or hydrogen chloride (HCl) absorb infrared

radiation, these molecules are short-lived in the atmosphere owing to their reactivity and solubility. Therefore, they do not contribute significantly to the greenhouse effect and usually are omitted when discussing greenhouse gases.

4.2.2 Greenhouse gases

Atmospheric absorption and scattering at different wavelengths of electromagnetic waves. The largest absorption band of carbon dioxide is in the infrared.

Greenhouse gases are those that absorb and emit infrared radiation in the wavelength range emitted by Earth. In order, the most abundant greenhouse gases in Earth's atmosphere are:

- Water vapor (H₂O)
- Carbon dioxide (CO₂)
- Methane (CH₄)
- Nitrous oxide (N₂O)
- Ozone (O₃)
- Chlorofluorocarbons (CFCs)

Atmospheric concentrations of greenhouse gases are determined by the balance between sources (emissions of the gas from human activities and natural systems) and sinks (the removal of the gas from the atmosphere by conversion to a different chemical compound). The proportion of an emission remaining in the atmosphere after a specified time is the "airborne fraction" (AF). More precisely, the annual airborne fraction is the ratio of the atmospheric increase in a given year to that year's total emissions. Over the last 50 years (1956–2006) the airborne fraction for CO₂ has been increasing at $0.25 \pm 0.21\%$ /year.

4.3 Contribution of clouds to Earth's greenhouse effect

The major non-gas contributor to Earth's greenhouse effect, clouds, also absorb and emit infrared radiation and thus have an effect on radiative properties of the greenhouse gases. Clouds are water droplets or ice crystals suspended in the atmosphere [23].

4.4 Impacts on the overall greenhouse effect

analyzed how individual components of the atmosphere contribute to the total greenhouse effect. They estimated that water vapor accounts for about 50% of Earth's greenhouse effect, with clouds contributing 25%, carbon dioxide 20%,

and the minor greenhouse gases and aerosols accounting for the remaining 5%. In the study, the reference model atmosphere is for 1980 conditions .

The contribution of each gas to the greenhouse effect is affected by the characteristics of that gas, its abundance, and any indirect effects it may cause. For example, the direct radiative effect of a mass of methane is about 72 times stronger than the same mass of carbon dioxide over a 20-year time frame but it is present in much smaller concentrations so that its total direct radiative effect is smaller, in part due to its shorter atmospheric lifetime. On the other hand, in addition to its direct radiative impact, methane has a large, indirect radiative effect because it contributes to ozone formation. Shindell et al. (2005) argue that the contribution to climate change from methane is at least double previous estimates as a result of this effect [5, 10].

When ranked by their direct contribution to the greenhouse effect, the most important are

Compound	Formula	Concentration in atmosphere (ppm)	Contribution (%)
Water vapor and clouds	H ₂ O	10–50,000(A)	36–72%
Carbon dioxide	CO ₂	~400	9–26%
Methane	CH ₄	~1.8	4–9%
Ozone	O ₃	2–8 (B)	3-7%

4.5 Air pollution

Air pollution is the introduction of particulates, biological molecules, or other harmful materials into Earth's atmosphere, causing diseases, allergies, death to humans, damage to other living organisms such as animals and food crops, or the natural or built environment. Air pollution may come from anthropogenic or natural sources. The atmosphere is a complex natural gaseous system that is essential to support life on planet Earth.

Indoor air pollution and urban air quality are listed as two of the world's worst toxic pollution problems in the 2008 Blacksmith Institute World's Worst Polluted Places report. According to the 2014 WHO report, air pollution in 2012 caused the deaths of around 7 million people worldwide, an estimate roughly matched by the International Energy Agency [19].

4.5.1 Pollutants

An air pollutant is a substance in the air that can have adverse effects on humans and the ecosystem. The substance can be solid particles, liquid droplets, or gases. A pollutant can be of natural origin or man-made.

Pollutants are classified as primary or secondary. Primary pollutants are usually produced from a process, such as ash from a volcanic eruption. Other examples include carbon monoxide gas from motor vehicle exhaust, or the sulfur dioxide released from factories. Secondary pollutants are not emitted directly. Rather, they form in the air when primary pollutants react or interact. Ground level ozone is a prominent example of a secondary pollutant. Some pollutants may be both primary and secondary: they are both emitted directly and formed from other primary pollutants.

4.5.2 Major primary pollutants produced by human activity include

- Sulfur oxides (SO_x) - particularly sulfur dioxide, a chemical compound with the formula SO_2 . SO_2 is produced by volcanoes and in various industrial processes. Coal and petroleum often contain sulfur compounds, and their combustion generates sulfur dioxide. Further oxidation of SO_2 , usually in the presence of a catalyst such as NO_2 , forms H_2SO_4 , and thus acid rain. This is one of the causes for concern over the environmental impact of the use of these fuels as power sources.
- Nitrogen oxides (NO_x) - Nitrogen oxides, particularly nitrogen dioxide, are expelled from high temperature combustion, and are also produced during thunderstorms by electric discharge. They can be seen as a brown haze dome above or a plume downwind of cities. Nitrogen dioxide is a chemical compound with the formula NO_2 . It is one of several nitrogen oxides. One of the most prominent air pollutants, this reddish-brown toxic gas has a characteristic sharp, biting odor.
- Carbon monoxide (CO) - CO is a colorless, odorless, toxic yet non-irritating gas. It is a product by combustion of fuel such as natural gas, coal or wood. Vehicular exhaust is a major source of carbon monoxide.
- Volatile organic compounds (VOC) - VOCs are a well-known outdoor air pollutant. They are categorized as either methane (CH_4) or non-methane (NMVOCs). Methane is an extremely efficient greenhouse gas which contributes to enhanced global warming. Other hydrocarbon VOCs are also significant greenhouse gases because of their role in creating ozone and prolonging the life of methane in the atmosphere. This effect varies depending on local air quality. The aromatic NMVOCs benzene, toluene and xylene are suspected carcinogens and may lead to leukemia with prolonged exposure. 1,3-butadiene is another dangerous compound often associated with industrial use.

- Particulates, alternatively referred to as particulate matter (PM), atmospheric particulate matter, or fine particles, are tiny particles of solid or liquid suspended in a gas. In contrast, aerosol refers to combined particles and gas. Some particulates occur naturally, originating from volcanoes, dust storms, forest and grassland fires, living vegetation, and sea spray. Human activities, such as the burning of fossil fuels in vehicles, power plants and various industrial processes also generate significant amounts of aerosols. Averaged worldwide, anthropogenic aerosols—those made by human activities—currently account for approximately 10 percent of our atmosphere. Increased levels of fine particles in the air are linked to health hazards such as heart disease, altered lung function and lung cancer.
- Persistent free radicals connected to airborne fine particles are linked to cardiopulmonary disease. Toxic metals, such as lead and mercury, especially their compounds.
- Chlorofluorocarbons (CFCs) - harmful to the ozone layer; emitted from products are currently banned from use. These are gases which are released from air conditioners, refrigerators, aerosol sprays, etc. CFC's on being released into the air rises to stratosphere. Here they come in contact with other gases and damage the ozone layer. This allows harmful ultraviolet rays to reach the earth's surface. This can lead to skin cancer, disease to eye and can even cause damage to plants.
- Ammonia (NH₃) - emitted from agricultural processes. Ammonia is a compound with the formula NH₃. It is normally encountered as a gas with a characteristic pungent odor. Ammonia contributes significantly to the nutritional needs of terrestrial organisms by serving as a precursor to foodstuffs and fertilizers. Ammonia, either directly or indirectly, is also a building block for the synthesis of many pharmaceuticals. Although in wide use, ammonia is both caustic and hazardous. In the atmosphere, ammonia reacts with oxides of nitrogen and sulfur to form secondary particles.
- Odors' — such as from garbage, sewage, and industrial processes
- Radioactive pollutants - produced by nuclear explosions, nuclear events, war explosives, and natural processes such as the radioactive decay of radon [24].

4.5.3 Sources

There are various locations, activities or factors which are responsible for releasing pollutants into the atmosphere. These sources can be classified into two major categories.

4.5.3.1 Anthropogenic (man-made) sources

- **Stationary sources** include smoke stacks of power plants, manufacturing facilities (factories) and waste incinerators, as well as furnaces and other types of fuel-burning heating devices. In developing and poor countries, traditional biomass burning is the major source of air pollutants; traditional biomass includes wood, crop waste and dung.
- **Mobile sources** include motor vehicles, marine vessels, and aircraft.
- Controlled burn practices in agriculture and forest management. Controlled or prescribed burning is a technique sometimes used in forest management, farming, prairie restoration or greenhouse gas abatement. Fire is a natural part of both forest and grassland ecology and controlled fire can be a tool for foresters. Controlled burning stimulates the germination of some desirable forest trees, thus renewing the forest.
- **Fumes** from paint, hair spray, varnish, aerosol sprays and other solvents
- **Waste deposition** in landfills, which generate methane. Methane is highly flammable and may form explosive mixtures with air. Methane is also an asphyxiant and may displace oxygen in an enclosed space. Asphyxia or suffocation may result if the oxygen concentration is reduced to below 19.5% by displacement.
- **Military resources**, such as nuclear weapons, toxic gases, germ warfare and rocketry [25].

4.5.3.2 Natural sources

- Dust from natural sources, usually large areas of land with little or no vegetation
- Methane, emitted by the digestion of food by animals, for example cattle
- **Radon gas** from radioactive decay within the Earth's crust. Radon is a colorless, odorless, naturally occurring, radioactivenoble gas that is formed from the decay of radium. It is considered to be a health hazard. Radon gas from natural sources can accumulate in buildings, especially in confined areas such as the basement and it is the second most frequent cause of lung cancer, after cigarette smoking.
- Smoke and carbon monoxide from wildfires
- **Vegetation**, in some regions, emits environmentally significant amounts of Volatile organic compounds (VOCs) on warmer days. These VOCs react with primary anthropogenic pollutants—specifically, NO_x , SO_2 , and anthropogenic organic carbon compounds — to produce a seasonal haze of secondary pollutants. Black gum, poplar, oak and willow are some examples of vegetation that can produce abundant VOCs. The VOC production from these species result in ozone levels up to eight times higher than the low-impact tree species.

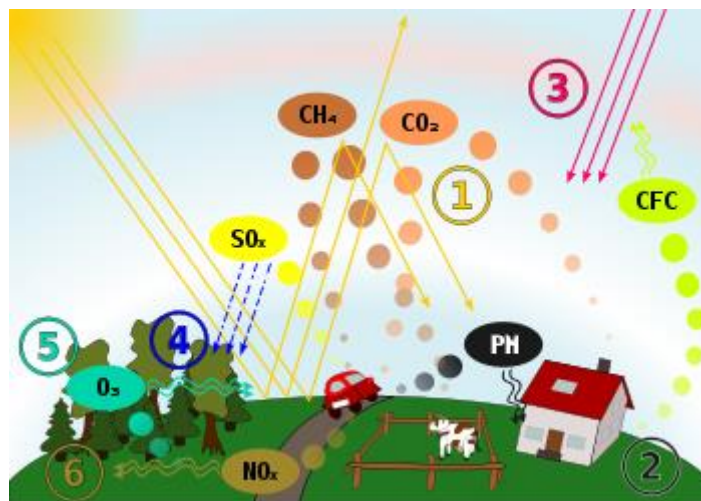
- Volcanic **activity**, which produces sulfur, chlorine, and ash particulates

4.6 Emission factors

Air pollutant emission factors are reported representative values that attempt to relate the quantity of a pollutant released to the ambient air with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant (e.g., kilograms of particulate emitted per tonne of coal burned). Such factors facilitate estimation of emissions from various sources of air pollution. In most cases, these factors are simply averages of all available data of acceptable quality, and are generally assumed to be representative of long-term averages.

There are 12 compounds in the list of persistent organic pollutants. Dioxins and furans are two of them and intentionally created by combustion of organics, like open burning of plastics. These compounds are also endocrine disruptors and can mutate the human genes.

The United States Environmental Protection Agency has published a compilation of air pollutant emission factors for a multitude of industrial sources. The United Kingdom, Australia, Canada and many other countries have published similar compilations, as well as the European Environment Agency [26].



Chapter Five

Conclusion and Recommendation

5.1 Conclusion

Currently the air contains 380 ppm of carbon dioxide which is the main gas that causes global warming, compared with the 275 ppm that existed in the atmosphere before the Industrial Revolution, and here we note that the amount of carbon dioxide concentration in the atmosphere has become the highest at 30 % lower than it was before the Industrial Revolution concentration.

The amount of methane concentration increased to twice the amount of focus before the Industrial Revolution, as well as carbon dioxide increase by 4% per annum from the current ratios, either nitrous oxide has become the highest at about 18% of the amount of focus before the Industrial Revolution.

5.1.1 We also note the following

- The water level rose in the seas of 0.3 to 0.7 feet over the past century.
- The temperature rose between 0.4 to 0.8 ° Q during the last century, according to a report of the International Commission on Climate Change of the United Nations.
- Rapid output of global warming as rising temperatures will eliminate three-quarters of the accumulated snow on the peaks of the Alps by 2050, causing devastating floods in Europe and considered this a warning must be alert to him.
- Also, from the results of global warming, rising sea 48 cm level which could threaten buildings, roads, power lines and other infrastructure in the same climate sensitive areas, scientists say sea level rise rates contained in the report could engulf Manhattan in New York water until Wall Street.
- In the Himalayas and found 20 glacial lake in Nepal and 24 glacial lakes in Bhutan has been inundated dissolved over the icy Himalayan summit, threatening crops and property drowning and floods to the lakes for ten years to come.
- Scientists likely reason for this is these lakes filled with ice water dissolved by the Global Environment Program found that Nepal temperature one degree centigrade rate has increased and the ice cover over Bhutan falls 30 to 40 meters per year and the floods of water ice made Bhutan and Nepal authorities assess the levees to ward off dangers these floods.

- The research published in the journal Nature, Nature on 16 second Novmbertharin in 2005 has shown that if the cause of global warming on the melting of rivers, mountains and ice blocs annual snow, it is likely to face the communities that depend on these sources of devastating natural disasters, and also as a result of climate warming the world over the past century half a degree Celsius taking the ice at the poles and the tops of the mountains above the Australian to melt significantly noted climate scientists that the winters have increased during the last three decades warmer than it was before and failed epochs Valrabie comes early for his appointments.
- This Arjehouna of global warming world, John Morgan Ali and attached this phenomenon puzzling saying that Australia is located in the southern hemisphere, and this rate of melting ice legacy icy environment might lose during this century has been observed that the trees in the area semi-polarity there are height has increased than ever before have increased a height of 40 meters than usual for a quarter of a century.
- This cautionary early for the rest of the world index because the increase of global warming environmentally damaging in another by zones may occur and this environmental splurge on the planet that could get lost ice disappears completely over it during this century and the ice has effects on the temperature and climate and monsoon.
- Also, the results of global warming, the extinction of many species of birds and plants Experts have confirmed that about 70 species of frogs have become extinct because of climate change, and that the dangers surrounded by between 100 to 200 species of animals that live in cold regions.
- Also contributes to the greenhouse to increase the spread of endemic diseases and epidemics such as malaria, dengue fever and typhoid, cholera rate due to the migration of insects and animals of delivery of its places in the south to the north, as well as due to the high heat and humidity and a lack of clean drinking water.
- The researchers have found that the high temperature leads to the destruction or decrease the productivity of some natural habitats vital, especially the coral reefs and tropical forests, one of the most important habitats on the planet and the most tender of humanity, followed by increasing the extinction of organisms rates are a direct result of the destruction of such habitats and not a lot of its objects the ability to adjust to the new changes.
- On the other hand this serious environmental imbalance leads to increase the proportion of arid land agriculture and low productivity as a direct result of increased drought ratio was affected a large number of

agricultural crops adversely change the temperature and climate and changing patterns of rain and snow, ocean currents and the high salinity and acidity of sea water, and the consequent increase droughts, forest fires and storms unit and other climatic disturbances[5].

5.2 Recommendation

5.2.1 Reactions to Global Warming

Common agreement among scientists has led to a continuous rise in global temperatures to increase that some UN bodies and the work of some individuals in response to global warming. It comes reactions are either trying to alleviate the causes or trying to cope with global environmental change.

5.2.2 Dilution of the causes

5.2.2.1 Reduce greenhouse gas emissions

The first global agreement to reduce greenhouse gas issue is the Kyoto Protocol, which is the development of the United Nations Framework Convention on Climate Change, which was negotiated about them in 1997. This includes the protocol now more than 160 countries and 55% of greenhouse gas emissions globally. But the United States and Kazakhstan did not sign the agreement despite the fact that the United States is the largest source of greenhouse gases globally.

Many environmental groups are encouraged individual action against global warming also encourages community and regional actions to reduce them. As some have suggested identifying a fixed share of the global production of fossil fuels direct biggest emissions of carbon dioxide.

There are also commercial actions on climate change, this includes efforts to improve the efficient use of energy and some attempts to use alternative fuels. In January 2005 the European Union announced a European Union project to emissions trading, where companies lend themselves together with governments to reduce emissions or buy emissions credits from the owners of at least the limit. Australia also announced in 2008 to reduce carbon pollution plan. US President Barak Obama announced his economic plan for emissions trading globally.

5.2.2.2 Climate Engineering

The use of climate engineering (Geoengineering) will ensure balanced development of the natural environment on a large scale to suit human needs. Addressing greenhouse gas -one of engineering applications of the Climate looking remove these gases from the atmosphere by carbon dioxide to isolate.

5.2.2.3 Coping

Global warming affects coverage, and therefore there are many proposals for measures to cope with global warming in all areas. This starts from simple solutions such as the use of air conditioners even large solutions like emigrate areas threatened by rising sea levels.

In the agriculture sector, which includes the selection of appropriate crops to adapt to new climate conditions? For example, farmers grow in Orissa in India rice platoon "Tchambisoar" which bears the floods. In Africa, it was discovered that with increased rainfall or falling farmers shifting between crops that consume large amounts of water and the drought tolerant crops. The proposed measures also include the construction of dams and changes in health care and to intervene to protect endangered species.

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