UNITED STATES MARINE CORPS

LESSON PLAN

CONSTITUENTS OF THE ATMOSPHERE

INTRODUCTION:

1. Gain Attention. Have you ever wondered how clouds are suspended in the air? Have you ever wondered why clouds don't fall to the ground?

2. Overview. The atmosphere is the vast gaseous envelope of air that surrounds the Earth. Its boundaries are not easily defined. The atmosphere contains a complex system of gases and suspended particles that behave in many ways like fluids. Many of its constituents are derived from the Earth by way of chemical and biochemical reactions. This period of instruction provides a detailed overview of some of the various components that compose the atmosphere.

3. Introduce Learning Objectives.

   a. Terminal Learning Objective. Without the aid of references, state which atmospheric gases are the most abundant, which ones change in values year to year, and which ones remain the same?

   b. Enabling Learning Objective(s). Without aid of references, define which gases are heaviest in weight, which gases have the highest percentage in the atmosphere, and which atmosphere gases pose health problems.

4. Method/Media. This period of instruction will be taught using the lecture method with aid of QMMCBT-001 "Introduction to the Dynamics of the Atmosphere".

5. Evaluation. The student(s) will not be evaluated at the conclusion of the class; however there will be a question and answer segment.

TRANSITION. The envelope of air that surrounds our planet is a mixture of many discrete gases, each with it own physical properties, in which varying quantities of tiny solid and liquid particles may be suspended for periods of time.

BODY:

1. Major Atmospheric Components. Table 1 lists the eleven most abundant gases found in the Earth's lower atmosphere by volume. Of the gases listed, nitrogen, oxygen, water vapor, carbon dioxide, methane, nitrous oxide, and ozone are extremely important to the health of the Earth's biosphere. The two (2) main components that make up 99% of the atmosphere are Nitrogen and Oxygen.

Table 1 - Major atmospheric components.

Name of Gas	Molecular Composition	Percent By Volume	Approx. Molecular Mass
Nitrogen	N_2	78.08	28
Oxygen	O_2	20.94	32
Argon	Ar	.93	40
Carbon Dioxide	CO_2	.03	44
Neon	Ne	.0018	20
Helium	He	.0005	4
Ozone	O_3	.00006	48
Hydrogen	H_2	.00005	2
Krypton	Kr	Trace	------
Xenon	Xe	Trace	------
Methane	CH_4	Trace	------
Water Vapor	H_2O	1-4	18

a. The table above indicates that nitrogen and oxygen are the main components of the atmosphere by volume. Both of these gases have very important associations with life. Nitrogen is removed from the atmosphere and deposited at the Earth's surface mainly by specialized nitrogen fixing bacteria, and by way of lightning through precipitation. The addition of this nitrogen to the Earth's surface soils and various water bodies supplies much needed nutrition for plant growth. Nitrogen returns to the atmosphere primarily through biomass combustion and denitrification (Conversion of nitrates into gaseous nitrogen and nitrous oxide).

b. Oxygen is exchanged between the atmosphere and life, such as plants, animals, and humans, through the processes of photosynthesis and respiration. Photosynthesis produces oxygen when carbon dioxide and water are chemically converted into glucose with the help of sunlight. Respiration is the opposite process of photosynthesis. In respiration, oxygen is combined with glucose to chemically release energy for metabolism. The products of this reaction are water and carbon dioxide.

Transition. The atmosphere includes many gases and particles that vary significantly from time to time and from place to place. Although small in amount, these variable components have significant effects on weather and climate.

2. Variable Components. For the purposes of this period of instruction, the variable components that will be discussed include Water Vapor, Carbon Dioxide, Aerosols, and Ozone.

a. Water Vapor. The most variable gas on the table is water vapor (H_2O). Water vapor varies in concentration in the atmosphere both spatially and temporally. The highest concentrations of water vapor are found near the equator over the oceans and tropical rain forests. Cold polar areas and subtropical continental deserts are locations where the volume of water vapor can approach zero percent. Water vapor has several very important functional roles on our planet:

(1) It redistributes heat energy on the Earth through latent heat energy exchange.

(2) The condensation of water vapor creates precipitation that falls to the Earth's surface providing essential fresh water for plants and animals.

(3) It helps warm the Earth's atmosphere through the greenhouse effect.

b. Carbon Dioxide. Carbon Dioxide (CO_2), while present in only minute amounts (0.037%), is a meteorological important constituent of the atmosphere because it is an efficient absorber of longwave radiation transmitted by the Earth. This has a great influence on the heating of the Earth. The volume of this gas has increased by over 25 % in the last three hundred years. This increase is primarily due to human induced burning for fossil fuels, deforestation, and other forms of land-use change. Some scientists believe that this increase is causing global warming through an enhancement of the greenhouse effect. Carbon dioxide is also exchanged between the atmosphere and life through the processes of photosynthesis and respiration.

c. Aerosols. The movement of the free atmosphere is strong enough to keep a large quantity of minute particles suspended in the atmosphere. These particles may be solid or liquid in nature. Visible dust can sometimes cloud the sky, but these particles are actually too heavy to remain suspended for long periods of time. Still, many particles are microscopic in nature and can remain suspended in the atmosphere for very long periods of time. Particles originate from many sources, both natural and man-made. Examples of these particles include sea-salts from oceanic breaking waves, soil being blown into the air on windy days, smoke or soot from fires, ash and dust from volcanic eruptions, and so on. We call these particles *aerosols*.

(1) Aerosols are most numerous in the lower atmosphere near the primary source, the surface. However, the upper atmosphere also contains aerosols that are carried to great heights with strong vertically rising air currents or by meteoroids they have disintegrated as that passed through the atmosphere.

(2) From a meteorological standpoint, these particles are extremely important, as they (1) act as a surface on which water vapor may condense (hygroscopic nuclei) to form clouds and precipitation. (2) Aerosols can also absorb or reflect incoming solar radiation that directly affects the amount of sunlight that reaches the Earth's surface. (3) Aerosols contribute to the varied colors of orange and red at sunrise or sunset, an optical phenomenon we have all seen.

d. Ozone. Ozone's role in the enhancement of the greenhouse effect has been difficult to determine. Accurate measurements of past long-term (more than 25 years) levels of this gas in the atmosphere are currently unavailable. Moreover, concentrations of ozone gas are found in two different regions of the Earth's atmosphere.

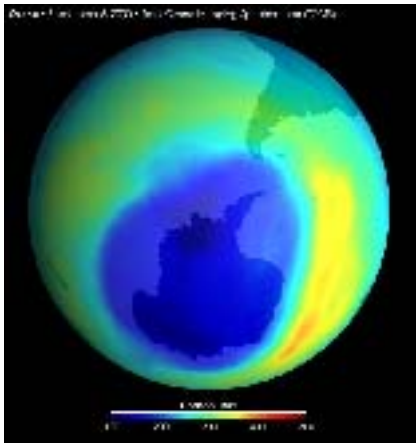

Figure 1 -- Stratospheric Ozone hole over Antarctica.

(1) The majority of the ozone (about 97 %) found in the atmosphere is concentrated in the stratosphere at an altitude of 15 to 55 kilometers above the Earth's surface. This stratospheric ozone provides an important service to life on the Earth as it absorbs harmful ultraviolet radiation from the Sun. In recent years, levels of stratospheric ozone have been decreasing due to the buildup of human created chlorofluorocarbons (CFCs) in the atmosphere. Since the late 1970s, scientists have noticed the development of severe holes in the ozone layer over Antarctica (Figure 1). Satellite measurements have indicated that the zone from 65° North to 65° South latitude has had a 3% decrease in stratospheric ozone since 1978.

(a) Natural Formation of Ozone. Ozone is created in two steps. First, high-energy ultraviolet (UV) rays are transmitted from the sun and strike ordinary oxygen molecules (O_2) and split them into two single oxygen atoms. Secondly, a free oxygen atom (O) combines with an oxygen (O_2) molecule to form a molecule of ozone (O_3).

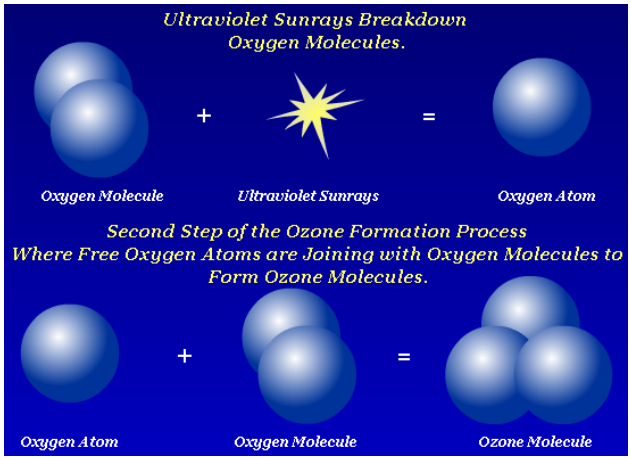

Figure 2 - The Ozone Formation Process.

When the ozone molecule absorbs ultraviolet sunrays, it will then split into an oxygen molecule and a single oxygen atom. Normally the single atom of oxygen will quickly collide with another oxygen molecule to form another ozone molecule. The process in which the ozone is continually broken down and recreated is sometimes referred to as the *ozone-oxygen cycle*.

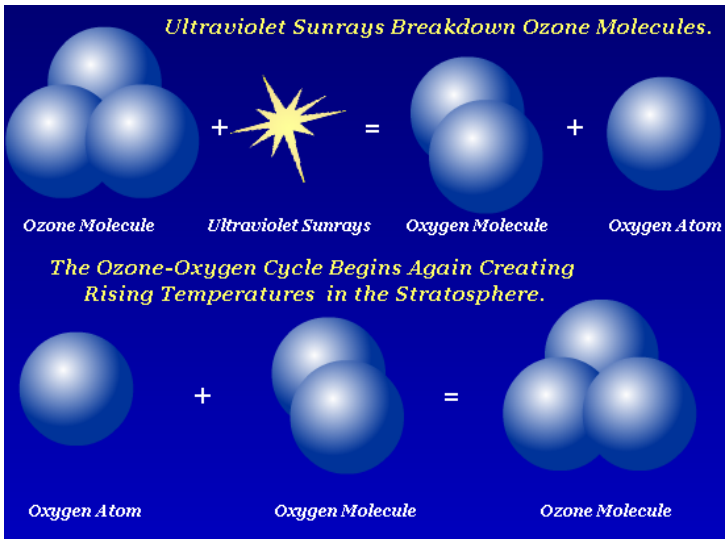

Figure 3 - Step two in the Ozone-Oxygen cycle.

(b) Ozone destruction by CFCs. Throughout the years, Scientists have learned that by using certain chemicals that contain chlorine, such as Chlorofluorocarbons (CFCs), that this leads to a loss of the Ozone in the stratosphere. The ozone in the stratosphere diminishes as CFCs drift upwards where they are bombarded by Ultraviolet Sunrays. The UV rays cause the CFCs molecules to breakup into single chlorine (Cl) atoms. These Chlorine atoms will then interact with surrounding ozone molecules by taking one of the oxygen atoms to form chlorine monoxide (ClO). This then leaves behind an oxygen molecule (O2). When this oxygen molecule runs into a chlorine molecule, it will steal an oxygen molecule, releasing the chlorine molecule back into space and essentially destroying more ozone. Every chlorine atom that makes its way to the top of the atmosphere is able to destroy many, many molecules of ozone.

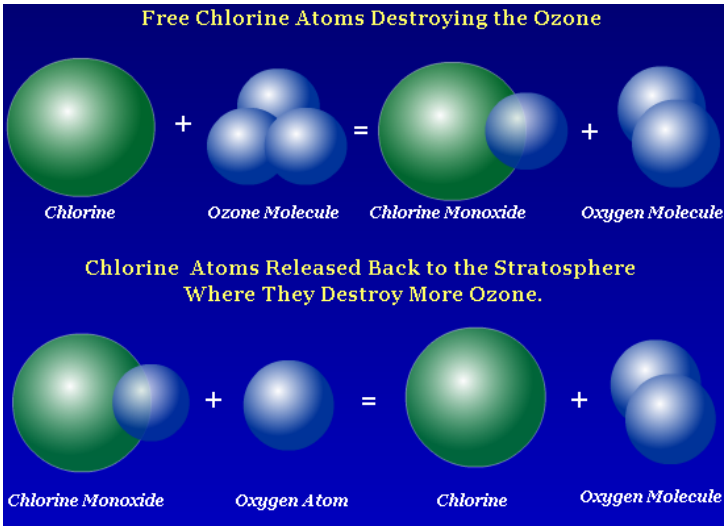

Figure 4 -- Destruction of the Ozone by CFCs.

(2) Ozone is also highly concentrated at the Earth's surface in and around cities. Most of this ozone is created as a by-product of human created photochemical smog. This buildup of ozone is toxic to organisms living at the Earth's surface, and whatever goes up - must eventually come down.

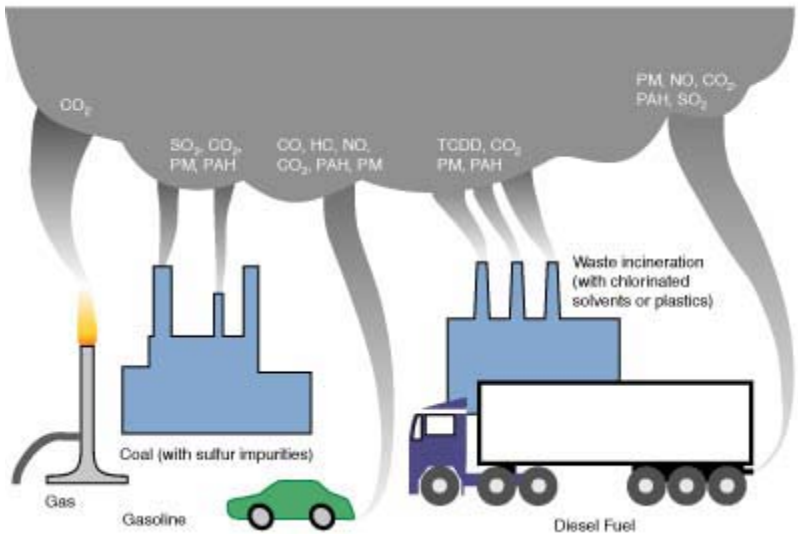

Figure 5 -- Creation of Ozone at the Earth's surface.

OPPORTUNITY FOR QUESTIONS:

1. Questions from the Class. At this time are there any questions regarding any of the material that was just presented to you?

2. Questions to the Class.

a. QUESTION. What is the heaviest gas?
b. ANSWER. Ozone.

c. QUESTION. What atmospheric constituent allows for the condensation of water vapor?
d. ANSWER. Aerosols, such as smoke, salt, soot, soil, etc…

e. QUESTION. Name two (2) of the components that are considered variable in the atmosphere?
f. ANSWER. Water Vapor, Carbon Dioxide, and Ozone.

SUMMARY: This period of instruction covered the major and variable components that compose the atmosphere. The variable components of water vapor, aerosols, and ozone were introduced and their meteorological significances were discussed.

REFERENCE:

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