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Weather, Climate and Environmental Change

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INTRODUCTION:

Looking at the various records left by nature, we have found that global changes have taken place on earth throughout it's history. The question is why? This unit will attempt to help the student understand the complexities for getting definitive answers for these past and present happenings in our environment. We read many things these days from various sources about the cause and effect of what is happening in our present environment. The student needs to be made aware of past global changes on earth and the evidence for why these changes took place before believing everything they read.

BACKGROUND/WEATHER-CLIMATE

The average weather conditions of an area over a long period of time constitutes its climate. Some of the factors that determine these conditions are elevation, relationship to the equator, nearness to large bodies of water, size, topography, and location of landmasses. Though we are going to concentrate on landmasse positions and climate, it is necessary to have an understanding of the basic factors that go into determining the climate of an area.

As we know, students like hands on activities. To make the topic more interesting and meaningful, we will have the student do some activities that will help them better understand the effects positions of landmasses and large bodies of water have on climate. I think we should begin by measuring and researching some weather elements as these effects can be measured and observed over a smaller time scale than climate. By discussing why conditions might vary during the day and throughout the year and then discussing the global effects these would have on the earth over a long period of time,I believe, might help them better understand effects events have on climate over a long period of time.

Break the class into groups and discuss the basic weather elements and where each is found on a weather map.

1. Temperature

2. Air Pressure
3. Relative Humidity
4. Clouds—cover/types
5. Winds—speed/direction
6. Dew Point
7. Precipitation—past/present

TEMPERATURE

We probably should begin by talking about temperature. Temperature, which involves molecular activity, can be measured with a thermometer. To introduce this idea, a good lesson is found in “Introduction to Earth Science” by Norman Abraham, Donald Chaney , Michael Moores, Robert Swift, Jerome Notkin and published by Rand McNally Company 1972.

To start the student thinking, place a one hole stopper containing a 30 cm glass tube with a plug of colored water that will move up or down into a flask containing only air. Covering and uncovering the flask with your hand will cause the plug to rise or fall. Have the students explain why this happens. You might also want to try using a two hole stopper and inserting a thermometer into one of the holes to see if a change in temperature can be observed. Trial and error? (see fig. 1) We are aware that temperatures at or near the equator are higher than those at or near the poles. What could cause some of these differences?

An activity that appears in several textbooks is to take a flashlight and shine it on graph paper both head on an at an angle from the same height. Have the students notice the light intensity and also the area covered. After doing this do the same thing but this time use a thermometer angled and perpendicular to the light source and record the temperature over a period of time. These activities should help the student realize that a locations latitude has an effect on the daily temperature. You might also bring in the fact that the sun”s rays also travel through more atmosphere away from the equator thus filtering, absorbing, and reflecting more energy than near the equator.

Temperature is also affected by altitude. As we ascend into the atmosphere the temperature decreases. Show the class pictures of areas that are nice and green and warm but in the background there are mountains covered with snow. Ask them how this could happen. Mountain building, by subduction, is one of the results of Plate Tectonics. Mountains have a bearing on the precipitation and temperature of an area by causing the air to condense and cool as it rises over the mountain.

Ocean currents can also affect the temperature of an area by bringing warm or cool currents to an area which cause conditions to be more stable by preventing wide temperature ranges as water warms more slowly than

land and also cools off less rapidly than land.

A heat exchange experiment is helpful at this time. Fill a styrofoam cup with hot water and another with cold water. Cover and connect each cup with a metal rod. Place a thermometer in each cup and observe the temperature changes in each cup and the final temperature in each cup. Oceans also effect the temperature of an area by cloud formation. As evaporation takes place at the surface it rises, cools and forms clouds. These clouds block out radiation from the sun which in turn causes the oceans to cool off. After cloud formation is reduced, the oceans will again begin to absorb radiant energy from the sun and the warming trend will begin again.

A way of observing the effects of blocking solar radiation is to check the effects of the oil fields burning in Kuwait. You will see that the temperature has decreased due to the smoke blocking out the radiation from the sun.

Other activities that can be performed are the heating and cooling of sand and water, the heating and cooling of water in a shiny aluminum container and a black container to help the student realize how water, land and ice can effect temperature and heat.

Air Pressure

Air pressure is affected by temperature, water vapor and elevation. We measure air pressure with an instrument called a barometer. This instruments indicates the condition of the atmosphere. As the air rises the pressure lessens causing the barometer to have a lower reading. If this air is saturated at ground level it will condense to a liquid at higher cooler elevations. The opposite happens for high pressure. Dry cool air descends causing the barometer to register a higher reading.

Relative Humidity

Relative humidity can be measured with a wet and dry bulb thermometer called a psychrometer. This gives an indication as to how much water vapor is in the air compared to how much it can hold at that temperature and pressure.

CLOUDS

Clouds are formed when moisture in the air condenses around solid particles in the atmosphere. There are three basic cloud types and these three types combine with one another to form all the other cloud types. Each is associated with a certain type of weather. (see fig. 2)

The three main types are:

1. Cumulus: Low level & puffy clouds
2. Stratus: Middle level & sheets
3. Cirrus: High level & thin

I suggest that you give each group a chart showing the shapes, elevations and names of the various cloud types to help them with their identification.

WIND

Wind is defined as air in motion. This movement is caused by warm air rising producing a low pressure area and cooler air replacing it from an area of higher pressure. The greater the difference in pressure between these two areas, the stronger the wind. Wind speed and direction can be found by using a wind vane and anemometer.

A fun activity might be to heat a surface and close by place a container of ice. Place a pin wheel or an object that releases smoke between the two surfaces to see if air motion can be detected.

DEW POINT

Dew point is the point at which water vapor in the air will condense to a liquid. We can find this temperature by placing some ice cubes in a glass of water to lower the temperature of the water. As the water temperature decreases record the temperature when moisture is first observed on the outside of the glass. This is called the dew point and if the temperature of the air reaches this point under the same conditions some form of precipitation will occur.

PRECIPITATION

Precipitation is water that falls to the earth in the form of rain, snow, sleet or hail. A precipitation gauge is used to measure the amount that has fallen. We should take time at the beginning of each period for about one week to measure these weather elements. Rotate the responsibilities of each group and check your results with the weather channel if possible. Use your bulletin board to post your information so each class can compare their results as each is taken at a different time during the day. You might want to use a chart similar to the one you will see on the next page.

Assign each group a research activity of finding weather conditions over the past year. Each group could do about a two month record. You might also want them to do a gnomon measuring shadow lines at various times of the year to show the sun’s elevation. This information can be found in the Interaction of Earth and Time text by Rand McNally.

CLIMATE ZONES:

There are three major climate regions on earth. Each is based on the average weather conditions of the area. (see fig. 3)

They are:

Polar—60-90 degrees north or south of the equator. Polar zones are the coldest of the three zones. Polar zones not only do not receive as much radiation from the sun as other latitudes but they also include ice caps which reflect the sun's rays slowing down the warming process.
Temperate—30-60 degrees north or south of the equator. The temperate zone is affected by both tropical and polar air masses. If nearer the polar latitudes one generally gets snow during the winter season and rain if nearer the tropical latitudes. Generally weather conditions vary more between seasons in this latitude than with the other two.
Tropical—0-30 degrees north or south of the equator. This zone has the highest temperatures and as it receives the most solar radiation throughout the year. An important event in this latitude is the monsoon. This brings much needed rain into the area during the summer season and when winter arrives the winds reverse their direction to become dry and cool.

Each region has it's special type of global wind pattern caused by this unequal heating which is influenced by mountains, direction of the prevailing wind, nearness to large bodies of water and the Coriolis effect which is the tendency for things in the northern hemisphere to turn to the right and just the opposite in the southern hemisphere because of earth rotation. (see fig. 4)

CAUSE AND EVIDENCE OF CLIMACTIC CHANGE

Man has not been on the earth since the beginning of time to measure and record the changes in the earth's climate. However, nature has done her part by leaving detectors that supply information about the early earth through:

1. Radioactive dating—oldest rock about 4.1 billion years old.
2. Tree rings—Accurate to about 10,000 years ago.
3. Fossils—Environment and evolution.
4. Ice Cores—Accurate to about 150.000 years ago.
5. Ocean floor samples—Accurate to about 160,000,000 million years ago.
6. Corals—Indication of changing sea level.

Now the question is why have these changes taken place?

1. Change of solar flux distribution on the earth.

A. Evidence now exists that the shape of the earth”s orbit changes from round to elliptical in 100,000 cycles.
B. The tilt of the axis of the earth changes at 40,000 year cycles.
C. Precession (wobbling)—operates on a 20,000 year cycle. These factors effect the amount and intensity of the solar radiation received by the earth causing it to become warmer or cooler. We are presently the farthest from the sun.

2. Continental Movement.

It is now quite evident that the positions of the continents have changed over time. The fit of the landmasses if put together like a jig-saw puzzle, the location of fossils after connecting the landmasses, location of rocks in mt. ranges after fit, paleomagnetism and evidence of glaciers in areas now to warm to support this activity. These movements affect the heat exchange on the earth as we demonstrated earlier with the investigations with land, water, shiny and dark objects. If you look at fig. 5 you will notice that the landmasses are moving toward the northern hemisphere. This movement makes more land available near the poles for ice build up thus affecting sea level and temperature.

3. Environmental

As life evolved, the composition of the atmosphere changed. As carbon dioxide decreases in the atmosphere the earth becomes cooler, ice storage increases and sea level lowers. The opposite occurs when carbon dioxide in the atmosphere is increased. Increasing the water vapor in the atmosphere might stimulate cloud formation blocking out radiation from the sun and cause the earth to cool down. As the earth cools down, there is less cloud formation and a warming trend may begin. This cycle probably keeps repeating itself.

4. Changes in the Solar Constant

Changes in the solar constant or the output of light from the sun has increased with time. 30 million years ago we received 30% less heat from the sun.

PLATE TECTONICS AND CONTINENTAL DRIFT

To me “curiosity killed the cat but satisfaction brought him back” can best describe why man has and continues to learn more about the world we live in. An example would be people not listening to the church teaching of the earth being about 6,000 years old and not changing. James Hutton was one such person. His observations of extinct volcanoes, igneous rock intrusion (prevailing belief at that time was all rocks were formed by deposition),rate of erosion of an ancient wall which was built in 200 AD that did not show effects of

erosion made him realize that it would take millions of years for a mountain to erode and finally his observations of rock layers not all being horizontal gave more evidence of a dynamic earth. It was observed that fossils of the same organism on continents thousands of miles apart, glacial deposits in tropical latitudes, same rock structures in mountains separated by oceans, and the shape of the continents. Alfred Wegner put these continents together and called it Pangea which means all land. His idea did not get support because at that time no one could explain what forces could move these large masses of land.

We now have the information to answer that question. We know the earth's surface consist of plates surrounded by mid-ocean ridges and trenches. These plates float on a layer of the mantle called the Asthenosphere. A way of showing how this operates is to place some wood blocks together in a pan containing corn syrup. Heat the corn syrup and have the student observe the motion of the wood blocks due to the convection movement within the corn syrup. The movement of plates result in their coming into contact with other plates. When this happen they may:

1. Diverge—drift apart
2. Convergent—come together
3. Transform—slide/grind past

The above movements are important as they have an impact on the climate of an area. For example, mountain building has a bearing on the amount of moisture and area will receive, drifting apart changes their latitude which influences the amount of solar radiation and materials escaping into the atmosphere from these activities affect the atmospheric composition. Look at these fig. 5 showing the positions of the earth's landmasses in the past, present and future.

THE EARLY CLIMATE

The lack of a rock record makes it difficult to study the early earth. Due to the movements of the earth's lithosphere the rocks have been recycled destroying any evidence that might have existed. The early atmosphere probably contained a plentiful amount of carbon dioxide for the greenhouse effect. The greenhouse effect was important as the sun's energy output was much less at this time. The earth's interior was warmer at this time and probably a great deal of volcanic activity was taking place. Theses eruptions are believed to have put water vapor into the atmosphere to form clouds blocking even more radiation from the sun cooling the earth thus starting the first rains.

Degassing of earth's interior furnished the water for ocean development. The oceans then stored heat and evaporation took place to supply the atmosphere with more water vapor for cloud formation and the cycle kept repeating itself.

There was no free oxygen in the atmosphere at this time so ozone could not be formed to filter the ultraviolet radiation which is harmful to living things. The climate was warm, humid and rainy when early life forms first appeared about 3.8 billion years ago. These primitive life forms probably added oxygen to the atmosphere

which helped to start the ozone layer.

Around 1.4 billion years ago, enter the eukaryotic cell. This is the greatest single leap in evolution as sexual reproduction allowed for a wider variety of organism to evolve. Increased oxygen production was also taking place.

PRESENT CLIMATE

Our present atmosphere consists mainly of nitrogen and oxygen but carbon dioxide, water vapor and pollutants play an important part in climate production. Although the amount of carbon dioxide in the atmosphere is small the effects are great. This gas is needed by organisms for photosynthesis,the process by which some organisms make their own food. This gas also plays an important part in the greenhouse effect. Water vapor varies from place to place in the atmosphere. Two main reason for this are the temperature of the air and the nearness of large bodies of water. As water vapor absorbs energy from the sun we can see it as an important climate factor. Pollutants are constantly being added to our atmosphere naturally or by man. These pollutants may effect the amount of solar radiation reaching the earth, increase the greenhouse effect and/or destroy the ozone layer. More information must be gathered about the past before we can truly tell their effects.

As for our present climate conditions, the polar zones average temperatures are below 10 degrees celsius. Little precipitation falls in this zone. Most areas of Alaska are in this zone.

The temperate zone has temperatures ranging from 10 to 18 degrees celsius and receives precipitation in the form of snow and rain. The continental United States are in this zone. The tropical zone has the highest temperatures and also very humid. It stays above 18 degrees celsius. Most areas of Hawaii are in this zone.

FUTURE CLIMATES

As landmasses continue to move toward the northern hemisphere and the other natural factors that we have mentioned continue to interact, we will have change. What we would like to learn is the effect that man made on the climate. We also would like to know how soon and to what extent will these changes occur.

Fig. 1

(figure available in print form)

Fig. 2

(figure available in print form)

Fig. 3

(figure available in print form)

Fig. 4

(figure available in print form)

Fig. 5

(figure available in print form)

PURPOSE: TO BECOME PROFICIENT IN MEASURING THE SEVEN BASIC WEATHER ELEMENTS.
GOAL: UPON COMPLETION OF THIS ASSIGNMENT, 100% OF THE STUDENTS WILL BE ABLE TO MEASURE EACH WEATHER ELEMENT AND KNOW WHERE EACH ELEMENT IS LOCATED ON A STATION MODEL FOR A WEATHER MAP.

PROCEDURE:

1. REVIEW THE USE AND OPERATION OF EACH WEATHER INSTRUMENT.
2. BREAK THE CLASS INTO GROUPS FOR MEASURING THE BASIC WEATHER ELEMENTS.
3. ALLOW 10-15 MINUTES AT THE BEGINNING OF EACH PERIOD TO MEASURE THE ELEMENTS.
4. ROTATE THE MEASUREMENT RESPONSIBILITIES FOR EACH GROUP DURING THE WEEK.
5. POST MEASUREMENTS DAILY.

APPLICATION:
CHECK THE RESULTS FROM THE CLASS POSTING OF DATA AND AS A GROUP WRITE DOWN THE REASONS WHY THE DATA IS NOT THE SAME EACH DAY.

EVALUATION:

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1. SHOW A STATION MODEL AND POINT TO VARIOUS LOCATIONS AND HAVE THE STUDENT WRITE DOWN WHAT ELEMENT YOU ARE POINTING.
2. HOLD UP DIFFERENT WEATHER INSTRUMENTS AND HAVE THE STUDENT NAME THEM AND TELL HOW EACH IS USED.

(figure available in print form)

PURPOSE: TO CHART TEMPERATURE AND PRECIPITATION IN THE NEW HAVEN AREA OVER THE LAST 50 YEARS.
GOAL: UPON COMPLETION OF THIS TOPIC, 100% OF THE STUDENTS WILL HAVE EXPERIENCE IN LOOKING UP PAST RECORDS OF TEMPERATURE AND PRECIPITATION AND GRAPHING THE

RESULTS.

PROCEDURE:

1. OBTAIN PARENTAL PERMISSION TO TAKE CHILDREN TO THE PUBLIC LIBRARY.
2. BREAK CLASS INTO FIVE GROUPS AND GIVE EACH GROUP A TEN YEAR PERIOD TO RESEARCH. (EX. 1940-49)
3. GRAPH RESULTS. TEMPERATURE VS. MONTH/YEAR (JAN/1940)

PRECIPITATION VS. MONTH/YEAR APPLICATION:

1. PLACE ALL GRAPHS TOGETHER, STARTING WITH 1940, ON THE WALL OR BULLETIN BOARD AND ALLOW THE STUDENTS TO STUDY THE RESULTS.
2. HAVE THE GROUPS WRITE DOWN REASONS WHY THEY THINK THESE TWO ELEMENTS HAVE CHANGED OVER TIME. (NOTICE-THEY THINK) EVALUATION: DECIDE HOW EFFECTIVELY THEY USED THE VARIOUS CLIMATE FACTORS IN DRAWING THEIR CONCLUSIONS.

(figure available in print form)
(figure available in print form)

STUDENT RESOURCES

VIDEOS: PLANET EARTH SERIES:

1. THE LIVING MACHINE

GOOD FOR PLATE TECTONICS

3. THE CLIMATE PUZZLE

GOOD FOR TRACING THE EARTH'S CLIMATE TRENDS

COMPUTER SOFTWARE:

CONTINENTAL DRIFT: PRENTICE-HALL

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