**Teacher Notes**

**Climagraphs**

**Overview/Objectives**

Students learn how to represent the climate of a place on a graph. They realize that there are many ways to design a climagraph – a good design can help people answer related questions about heating, cooling, freezing, water balance, etc. In the main activity, they learn about broad geographic patterns of climate by using deductive reasoning to match climagraphs with places on a map.

**Learner outcomes and standards**

After doing this Activity, a student should be able to:

1) create a climagraph from a table of monthly average temperature and precipitation for a place
(Standard 1: maps and other graphic representations of geographic information);

2) use deductive reasoning to match climagraphs with their locations on a map
(Standard 7: analyze physical patterns and processes);

3) list some United States analogues for major global environments (e.g., California - Portugal, Dakotas - Ukraine, Virginia - Japan) (Standard 7: analyze physical patterns and processes);

4) recognize the importance of climate as a driving force for many environmental systems and environment-related human activities, such as agriculture or outdoor recreation
(Standard 15: how physical systems influence human systems; effects of natural hazards).

Understanding of climate is an essential component of earth science. It is also good background for history and economics. This Activity promotes critical thinking by encouraging students to combine knowledge about atmospheric processes with facts about places in order to solve the matching problem.

**Resources**

Time: one to two 45-minute class periods, or ten or fifteen minutes each day for week or so

Multimedia units on Climagraphs, Seasonal Photos, Seasonal Precipitation in Africa (why the equatorial rainy belt moves), Isoline Maps (how to show climatic information on a map), Regions in Africa, Water Taps in Bulgaria, Vegetation Greenup in Tibet, and/or Altitude Zones in the Andes (all animated illustrations of deductive reasoning about climate)

Handout on hints for interpreting a climagraph.

**Classroom procedures**

1) Ask questions about climate and its consequences, or use one of the introductions described later.

2) If necessary, explain how to read a climagraph; you might use Part 1 of the multimedia unit and/or the Xtra presentation on Making a Climagraph to Solve the Water Balance.

3) Hand out the Activity and explain the goal – to match climagraphs with places on the map.

Part 3 of the CD unit on climagraphs is an animated explanation of eight questions that students could ask to help match climagraphs and places; N America Activity 3x – Questions is a summary of those questions. Use as many of these resources as students seem to need – some teachers prefer to have students try to rephrase the rules in their own words, in effect constructing the handout as a writing activity.

4) Optional: Use the CD units on Seasonal Climate in Africa, Water Taps in Bulgaria, and/or Vegetation Greenup in Tibet to illustrate deductive reasoning about climate.

**Setting up the activity**

Ask some questions about the relationship between climate and human activities (these are just illustrative of a vast array of possibilities; it's usually better to use a familiar place or a current headline about a place).

? Why do people in Texas usually have airconditioners in their cars?

? Why don't many teams like to play professional football outdoors in Minneapolis or Green Bay?

? Why don't people try to grow corn in parts of North Africa?

Obviously, climate is important. In fact, it is the driving force for many environmental systems. To illustrate this, ask about some things that occur in particular places with specific kinds of weather: changing leaves, migrating birds, crop harvests, river floods, forest fires, tornadoes, hurricanes, good surfing, hunting seasons, road pothole repair, severe smog, yacht racing, cross-country skiing, whatever might be familiar to your students. This lesson is about ways of describing and analyzing climate.

**Alternative introduction**

Consider the following numbers:

11 18 29 46 59 68 73 71 61 50 33 19

 1 1 2 2 3 4 3 4 3 2 1 1

? What do they mean? (Encourage students to write down what they think, then discuss in class. Hints: there are twelve numbers; maybe they have something to do with months of the year? In fact, they are the monthly average temperature and rainfall for a place.)

? Is there an easier way to show the numbers? (Try to elicit a suggestion to make a graph. Then explore several ways to make a graph; maybe some students could put ideas on the board.)

? Where is the place? Write down some possibilities. Then discuss. (Could it be Miami? No, Miami doesn't get that cold in winter).

The handout for today shows a special way to design a climagraph so that it tells us more than just temperature, rain, and snow. (Hand out and discuss.)

**Another alternative: What makes the weather in a place?**

A third approach is to formulate rules for climate by asking about the forces that cause particular kinds of weather to occur at specified times in specified places:

? Why is it usually colder in Norway than in Italy? (Norway is farther from the equator, and the rule is that the sun doesn't shine as directly on places at higher latitudes.)

? Why is it rainier in Thailand than in Tibet? (Thailand is closer to an ocean, which serves as a source of moisture.)

? Why is it snowier in Buffalo, New York, than in Buffalo, South Dakota? (They're both equally far north, but Buffalo is closer to sources of moisture: the Atlantic, Gulf, and Great Lakes.)

? Why does southern California often have fires in late summer? (Because it's hot and dry when the wind system that creates the tropical desert shifts north in summer.)

**Progress check** (a non-intrusive way to see whether students are on the right track)

Ask students to look at a sample climagraph:

? How many months are above room temperature?

? Which months have the most precipitation?

Students who can answer these questions are apparently able to read the climagraph.

**Ways to use the handout “Hints for Matching Places with Climagraphs”**

Attached to the Activity is a page of hints that a teacher could use in a variety of ways:

1) as a handout near the start, for students to read before the Activity,

2) as a teacher outline, to help in organizing a class discussion,

3) as a handout at the end, to summarize the Activity, or

4) as a key to grade written essays, in which students try to outline the causes of climate in a place,

**Concluding the activity**

Try to get students to summarize some basic principles of climate for the continent you are studying. Their statements of principles should have about as much causal and spatial detail as these:

1) High sun gives places near the Equator a higher average temperature than places near the Poles.

2) Mountains tend to be cooler and wetter than low areas around them.

3) Places that are farther from the oceans tend to be drier and more extreme in temperature.

4) Onshore winds bring rain to west coasts in the middle latitudes, especially in winter.

5) Land just east of mountains in the middle latitudes is usually drier than it otherwise would be.

6) Sinking air makes places near the Tropics dry, especially in summer.

7) Hurricanes tend to hit places about 20 degrees of latitude in late summer or autumn.

Don't forget to remind students that the point of the exercise is not just to learn the principles of climate. This knowledge becomes valuable when we realize how many environmental and economic systems depend on climate. For example, a combination of principles 2, 5, and 6 helps to explain why southern California cities must have elaborate systems to bring water from hundreds of miles away, at great cost.

**Frequently asked questions about climate: a sample dialog**

Try to redirect the student to use critical thinking rather than memorization

Student: Graph E; is that Riyadh or Tashkent?

(Mistaken response: "Well, it probably gets pretty hot in Riyadh; that’s close to Jerusalem, and it was really hot when I went there for a vacation a few years ago." Answering from experience or previous knowledge will help the student finish the Activity, and it might impress some students, but it doesn't further the point of the exercise – to apply analytical reasoning to explain the climate of places, rather than just learn facts about places.)

Redirection: Remember when we hypothesized that northern places, far from the Equator, have lower temperatures than places that are closer to the Equator? Let's use some deductive reasoning. Which one of these graphs has the lowest average temperature?

Student: Graph A?

Teacher: Right. That seems to answer it, but to make sure, let's ask another question. What makes for a big difference between summer and winter?

Student: I don’t know. What?

Teacher: Well, when you go to a beach, does the sand or the water tend to get hotter in the middle of the day? (Or cite some other experience that a student might use as a basis for generalization; for example, if a student is taking physics or general science, ask whether he or she has done a lab about specific heat).

I’ve seen a lot of different kinds of climagraphs. Why does the ARGWorld version put the two graphs on scales that allow them to overlap in some places?

First of all, there is no evidence that a graph with widely separate scales is actually easier to read. The goal of reading the graph is to get an idea about the seasonal differences in temperature and precipitation, and those are evident on any well-constructed climagraph. Second, as explained in the CD unit, the ARGWorld climagraph does a fairly good job of identifying seasons that have a moisture surplus or deficit. For farmers, foresters, and urban landscape architects, the moisture balance and the length of the growing season are the two key pieces of information about the environment in a place.

The CD mentions an equatorial rainforest. I’ve heard the term “tropical rainforest.” Which is correct?

The term “tropical rainforest” is probably more common, but it is technically wrong, because the rainforest is close to the equator, whereas the natural vegetation near the Tropic of Cancer and the Tropic of Capricorn is usually a scrub forest or even a desert, especially on the western sides of the continents. This is not the only place where common usage is technically incorrect: meteorologists talk about Arctic and Continental Polar or Maritime Polar airmasses, with the former usually much farther north than the latter, even though the Arctic Circle is thousands of miles south of the Pole!

What’s the single most common problem that student have with climagraphs?

A tendency to give up before really getting started. One good solution is to pick a climagraph and ask an absurd question about it. For example, point to one that has high temperatures and no rain and ask, “If I told you that this was the graph for Buffalo, New York, would you believe it?” If the student says no, ask why, and use the answer to help the student classify the graphs into groups – hot and cold places, northern and southern hemisphere, wet and dry, etc. Almost any grouping will simplify things, and most students can go on from there.

**Climagraphs**

**Glossary of Key Terms**

**climagraph:** special graph showing average temperature and total precipitation for every month

**continentality:** climatic consequence of distance inland from the ocean

**convective storm:** thunderstorm that occurs when heated air rises and causes rain; common in the afternoon near the equator; why equatorial rainforests occur where they do

**cyclonic storm:** rain or snow that occurs when warm airmass collides with a cold airmass; common in the middle latitudes, especially between 40 and 50 degrees of latitude

**equator:** line of zero latitude; dividing line between the northern and southern hemispheres

**elevation:** measure of distance above sea level (see the CD units on Altitude Zones in the Andes and Terrain Profiles in Afghanistan)

**freezing temperature**: the temperature at which water freezes (0ºC, 32ºF)

**high-sun season:** season when the sun is higher in the sky – May, June, July in the northern hemisphere; December, January, February in the southern hemisphere

**insolation:** amount of solar energy coming in to a place (see the CD unit on Solar Energy)

**latitude:** distance north or south of the Equator, defined by the angle from the equator

**maritime effect:** climatic consequence of location close to an ocean; opposite of continentality

**Mediterranean climate**: a climate with dry summers and mild, moist winters; places with Mediterranean climate include Greece, Italy, northern Africa, California, central Chile, southern Australia (see the CD unit on Water Taps in Bulgaria)

**monsoon:** summer rainy season at a place between the equatorial storm zone (ITCZ) and the tropical deserts (see the CD unit on seasonal precipitation)

**prevailing wind:** wind that blows most frequently from one particular direction; prevailing winds in the middle latitudes are from the west

**rainshadow:** dry area on the opposite side of a mountain from the direction of prevailing winds

**room temperature**: a temperature considered comfortable by most people; around 20ºC (68ºF)

**runoff:** extra water that flows into streams and rivers (see the CD unit on Battle Creek)

**subsidence:** zone of sinking air and generally dry conditions about 30 degrees of latitude away from where the sun is directly overhead (see CD unit on Regions in Africa)

**satellite image:** an image of the earth taken from a satellite; these images can convey a great deal of information about large areas of the earth

**water surplus**: more than is needed; a moisture surplus is the water left after plants take all the water they need

**water deficit:** less than is needed; a moisture deficit is a situation in which there is less water than plants need (see the CD unit on Water Budgets)

**Handout A: HINTS for matching PLACES with CLIMAGRAPHS**

First, look at the temperature curve on the graph.

1) **Hemisphere.** If July is colder than January, the place is probably south of the Equator.

The “low sun season” is in June and July for places in the southern hemisphere.

2) **Latitude.** If it’s hot in every month, the place is probably close to the Equator.

Average temperature tends to go down as you go away from the Equator, but the difference from winter to summer tends to increase. Summer in parts of Alaska can be almost as warm as in Brazil. The Arctic winter, however, is definitely not that warm!

3) **Continentality.** If winter is very different from summer, the place is probably inland,
 far from the moderating effect of an ocean or other large body of water.

Places that are at the same latitude and elevation tend to have the same average temperature. A place near an ocean, however, has less difference between winter and summer than a place that is inland, far from big bodies of water.

Next, examine the precipitation bars.

4) **Quantity.** If it rains every month, it’s near the Equator or about 45 degrees from it.

The earth has three major rainy belts -- a thunderstorm area near the Equator, and two airmass-collision zones about 45 degrees north and south of the Equator. In between the rainy zones, the earth has four dry areas -- at the poles, where the air is too cold to have much water, and near the Tropics of Cancer and Capricorn, where sinking air makes deserts such as the Sahara, Australian, Kalahari, and Mojave.

5) **“Summer” monsoon.** If heavy rains come in summer, the place is
 between the Equator and the tropics

Distinctly dry seasons are caused by a north-south shift of the Tropical desert climate. It shifts toward the Equator in winter, bringing dry conditions to places about 10 to 20 degrees north and south of the Equator.

6) **“Winter” rains**. If summers are dry and winters wet, the place is on a west coast.

The Tropical desert climate shifts toward the poles in the high-sun season, causing dry summer on the west coasts about 35 to 55 degrees of latitude (remember, summer is in January and winter in July in the southern hemisphere).

Third, look at another map (a real one, or a sketch that you have in your mind).

7) **Elevation.** If it’s colder than you expect, the place may be on a mountain.

Mountains force air to rise, cool, and lose moisture. Temperature goes down about 6 to 10 Celsius degrees for every 1000 meters you go up (3 to 5 Fahrenheit degrees every 1000 feet). A place near the top of a 10,000-foot mountain, therefore, will be 30 to 50 Fahrenheit degrees colder than near sea level.

8) **Rainshadow.** If it’s drier than you expect, the place may be “behind” a mountain.

Compared with a plain, a mountain will be rainier on the slopes that face the direction the wind comes from, colder on the summit, and drier in the "rainshadow" on the leeward side (away from the wind).

When you put all of these clues together, you should be able to tell roughly where a place is on the earth just by looking at its climagraph. That is actually a very useful skill – it means that you don’t have to memorize a lot of facts about a place; you just have to know where the place is in order to figure out what kind of weather it is likely to have!