Climate Activity 1

Frontiers of Science Seminar Activity Following Broecker's First Lecture

Introduction. The purpose of this activity is to learn to use maps to assess how an increase in global temperature could impact ecosystems, growth of deserts, agriculture, and malaria. For the purpose of this activity, we will analyze the effects of a 5 degree increase in temperature. This amount is at the high end of the range predicted in the IPCC Third Assessment Report - Climate Change 2001 for the amount of warming that might occur by the year 2200 (see Figure 5d of the *The Scientific Basis, Summary for Policymakers*).

Explanation of the Maps. Seven color maps are provided with this activity:

Map 1: January Temperature. The average temperature during the month of January is depicted in five degree intervals, with the hottest temperatures colored red and the coldest colored blue. Note that the temperature is hottest in the equatorial regions and coldest at the poles, and that the temperatures form crude bands that span the earth in the east-west direction. Note that the Northern Hemisphere is bluer than the Southern Hemisphere. The Northern Hemisphere is experiencing winter and the Southern, summer.

Example of the use of the map. Now imagine now that the earth is 5 degrees warmer. All the color bands would shift by one color. You can use this shift to estimate how the climate in different parts of the world might change. For instance, note that boundary between the yellow (above freezing) and blue (below freezing) temperatures crosses southern Europe and North America. All the regions north of this line can have significant snow cover. If five degrees of warming would occur, then this boundary would shift to the northern edge of the -5 to 0 degree (palest blue). France, Germany and much of the central US, for instance, would no longer have much snow accumulation. Summer temperatures in the northern fringes of Antarctica would also be above freezing.

Map 2: July Temperature. The map shows the average temperature during the month of July. Compared to Map1, the Northern Hemisphere is redder (Northern summer) and the Southern bluer (Southern winter).

Map 3: Global vegetation as seen from space. The color of the landmasses of the world indicate the amount of vegetation. The great rain forests of Brazil and equatorial Africa are dark green. The band of forests running across northern Europe and Asia are also strikingly visible. The great deserts of the world, including the Sahara in northern Africa, are bright yellow. The ice and snow of the polar regions are white. Many (though not all) of the boundaries between these regions run east-west across the world, reflecting the importance of temperature in governing the pattern of vegetation.

Map 4. Major World Ecosystems. The ecosystems of the world have been classified into 16 major types. Several are of particular importance to this activity:

Tundra: The band of blue that crosses the northern part of North America, Europe and Asia consists of bushes, mosses and grasses growing on top of permanently frozen ground (called permafrost).

Tiaga and broadleaf forests: The bands of red and green just south of the Tundra are heavily forest areas, with the Tiaga having mostly evergreen trees and the broadleaf forests mostly deciduous trees.

Agriculture is concentrated in Irrigated Land (bright red) Other Crop (dark red) and Settled Lands (pink). These lands are scattered around the world, but a conspicuous band crosses central North America, Europe and Asia.

Tropical Savanah (that is, grasslands, colored brown) borders the southern edge of the Sarhara desert.

Rainforest (dark green).

Map 5. World Population. The reddest color corresponds to a population density of 1000 people per square kilometer.

Example of correlating features on several maps. Note on the Population Map (Map 5) the highly populated (reddish) band crossing Africa just south of the Sahara desert. By correlating this region with the Ecosystem Map (Map 4), it is apparent that these “sub-Saharan” people are living in the “tropical savannah / montane” (grassland) ecosystem. The vegetation there is fairly sparse, as can been seen from the Global Vegetation map (Map 3). Note that the green band on that map is actually to the south of where these people are living!

Map 6. Incidence of malaria. The upper map shows areas of high malaria risk for three time periods, 1946 (yellow), 1966 (orange) and 1994 (red). This disease thrives where the temperatures are warm enough (and wet enough) for the mosquito to live long enough to transmit the disease between several people. Note that the area of the high risk regions has shrunk with time, mostly due to the use of pesticides (to control the mosquito that spreads the disease) and drugs (to prevent infection). The lower map gives the 1994 death rate (in deaths per year per 100,000 people living in an area). Note that death rate is much higher in central Africa than in India, even though the risk for both regions is shown as high in 1994 on both maps.

Map 7. Political Boundaries. (Just in case you need to know where they are!)

Activity Plan. The format of this activity is to divide the class into four work groups. Each group will be responsible for analyzing and reporting upon one of the following potential effects of temperature rise: Spread of Malaria, Loss of Northern Tundra, Changes in European and North American Agriculture, Changes in Agriculture in Sub-Saharan Africa.

Each group should work together for 10-15 minutes to analyze their effect (taking notes on their main findings). They should then select one (or more) of their members, who will make a brief (3-5 minute) oral report to the class. After each presentation, the class as a whole is invited to contribute further discussion.

Suggested things for each group to think about:

Group 1. Spread of Malaria.

1. Assume that in 1946 the northern and southern boundaries of malaria were mainly controlled by summer temperature (an exception would be desert areas that are so dry that the mosquitoes cannot breed). What is the minimum summer temperature for a region to have been high risk?

2. The areas that remain high risk in 1994 include not only the poorest countries of central Africa, but also moderately-well off countries in equatorial Asia. So poverty alone is not the full explanation of why malaria still remains a problem there. Climate is also involved: the rate at which mosquitoes can spread malaria is much higher in hot climates, so it is harder to control it there than in cooler regions. Use the 1994 data to estimate the minimum summer temperature at which malaria is "uncontrollable" today?

3. What countries that were not affected by malaria in 1946 might become affected if summer temperature rises by 5 degrees? Which population centers would be most affected?

4. What countries that now have a controllable malaria problem might have an "uncontrollable" one in 100 years?

5. How many more people might die per year?

Group 2. Loss of Northern Tundra.

1. What part of the world hosts the northern tundra ecosystem? Can you identify this region on the Vegetation and Political Maps?

2. Why is the northern tundra is a unique ecosystem? What animals live there? What peoples?

3. Let's assume that the southern boundary of the tundra is controlled by summer temperature (that is, too warm temperatures would allow the permafrost to melt). What temperature is the boundary?

4. How far north will the southern boundary of the Tundra move in the 5 deg global warming scenario?

5. What ecosystem will replace it? And how might that affect the people and animals there?

Group 3. Changes in European and North American Agriculture.

1. Where are the agricultural lands that cross the continents of North America and Europe (pink and red on the Ecosystem Map)? What countries are they in?

2. Suppose that the northern and southern boundaries of these agricultural lands are significantly controlled by summer temperature (that is, intensive agriculture requires temperatures that are neither too hot nor too cold). What temperature range is best?

3. Where would 5 degrees of global warming move these boundaries?

4. Suppose that agriculture moved into these new regions. What ecosystems would be displaced. What countries would be affected?

5. In some places the southern boundary is often bounded by desert. What would happen if the desert extendd further north? What population centers would be affected?

Group 4. Changes in Agriculture in Sub-Saharan Africa.

1. Where are the major population centers in Africa? Why is there a narrow, densely populated band along the northwestern coast? Why is there a band that crosses central Africa? Why are there no people in between the two bands?

2. What ecosystems do the people in the southern band mostly live in?

3. Let us assume that the southern boundary of the Sahara desert is mostly controlled by July temperature. How far south would it move if temperature were to rise by five degrees? What ecosystem might be displaced?

4. What peoples and countries would be affected? Suppose that they migrated south. Where would they go?