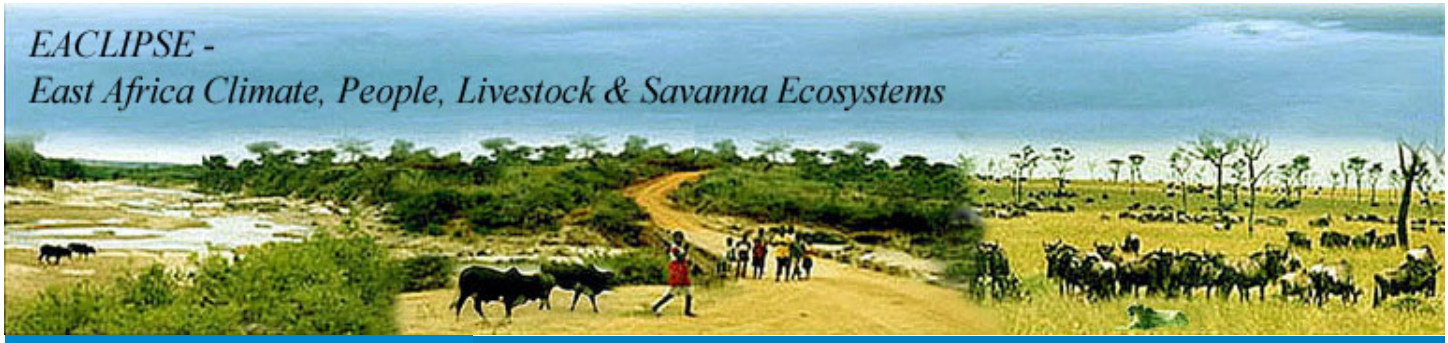

Time:
Two 50-minute periods

Summary:
In this lesson, students will graph temperature data from two different locations in East Africa and compare the rates of increase in order to understand how climate change varies in different ecosystems (highland savanna vs. coastal). They will then pose scientific questions about the effects of changes in temperature and make predictions about how savanna vegetation, livelihood systems, and land management may change as a result of changes in temperature. This lesson gives students the opportunity to analyze real data, to think like a scientist, and to recognize that climate change is complex, variable, and dependent on many different factors that scientists are trying to understand.

Materials:
- Computer with internet access
- Projector
- Digital projector
- Overhead projector
- Graph paper (or Microsoft Excel)
- Rulers

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Changing Temperatures

Objectives

Students will be able to:
- graph temperature data and find the line of best fit.
- compare the rate of change in temperature in two different ecosystems.
- pose scientific questions based on the data.
- predict possible effects of temperature change.

Background

Researchers have collected temperature data in various locations in East Africa from 1961through 2005. The data show increases in temperature over this time period, occurring at different rates in different locations, demonstrating that there is variation in the rate of change in different ecosystems.

When temperatures rise, evaporation and transpiration increase, resulting in a drier environment. Higher temperatures affect what vegetation will grow in an ecosystem, including crops and forage for animals, affecting people's livelihood and their ability to survive in a given ecosystem. As people adopt new livelihood systems in response to changing temperatures, that will affect land management in the savanna. Changes in land management can affect the existing vegetation, including species composition and ground cover. Inadequate ground cover can contribute to higher local temperatures and lower amounts of CO_2 absorbed by plants, in turn contributing to climate change.

Vocabulary

Evaporation
Transpiration
Scatter plot graph
Line of best fit

Introduction to Climate Change in East Africa

Procedure

1. Activate students' prior knowledge by asking them:

- What do you remember about temperature change in East Africa from the previous lesson? (They should remember that there is evidence of temperatures rising.)

- Where do temperatures fit into the savanna human-land-climate system loop? Climate change)

- What effects are changing temperatures having? (They are changing vegetation, which affects livelihoods and land management.)

- Do you think that temperatures are changing at the same rate all over East Africa? If you predict differences, what do you think might cause them?

We will be looking at some actual temperature data collected in Tanzania at two different locations from 1961-2005: Arusha and Zanzibar. Each location represents a different ecosystem.

2. Hand out the student maps of Tanzania. Have students search Google Earth to mark the locations of Arusha and Zanzibar. Alternatively, you can view it on a classroom projector or make an overhead of the teacher map for students to see the locations of the two sites.

3. Continue discussion:
Arusha is located in inland Tanzania, in a highland savanna ecosystem. Zanzibar is an island off the coast of mainland Tanzania and has a coastal ecosystem.

- How do you think temperatures might be affected by the different locations?

4. Hand out Arusha temperature data sheet to half of the class. Hand out Zanzibar data sheet to the other half of the class. You can have them work individually or in pairs. Have students graph the data and find the line of best fit for their data set. The data are in degrees Celsius.

For assistance in explaining how to find the line of best fit, a tutorial is available at: http://serc.carleton.edu/mathyouneed/bestfit.html

Alternatively, you can have students use a computer program (such as Microsoft Excel) to enter the data points to get the line of best fit. The data are provided to you in Microsoft Excel files, so all students have to do is select "best line of fit" in the Excel program to generate the graph. If you wish to skip this step all together, you can use the graphs provided.

5. Hand out the student reflection sheet.
Once they have the line of best fit, have students enter data from their graph onto their sheet.
Have students calculate the temperature change from 1961 to 2005 for their location using the average temperatures for 1961 and 2005 shown by the line of best fit. Subtracting the 1961 best fit point from the 2005 best fit point will give the change from 1961-2005.

You may wish to have your students convert those temperatures to degrees Fahrenheit so they can more easily relate to how hot that is and how many degrees the temperature has risen.

6. Have students representing each ecosystem share their results so that all students have data for both locations. Remind them that Arusha represents the highland savanna ecosystem, and Zanzibar represents the coastal ecosystem.

Students can then answer the reflection questions on their own or working in pairs.

7. Discuss students' answers to the reflection questions as a class:

- Are temperatures increasing or decreasing in the two ecosystems?

- Which ecosystem had higher average temperatures to begin with?
- Which ecosystem had the greatest increase in temperature?
- As a scientist, what questions would you pose to find out why there are differences in the rate of temperature change in these two ecosystems?
- In the savanna ecosystem, how might increasing temperatures affect savanna vegetation, livelihood systems, and land management? (Refer to the savanna human-land-climate system loop)
- If you lived in the East African savanna, what would your greatest concern be about rising temperatures?

8. Conclusion
In the next lesson, we will look at changes in water availability as a result of climate change.

Assessment

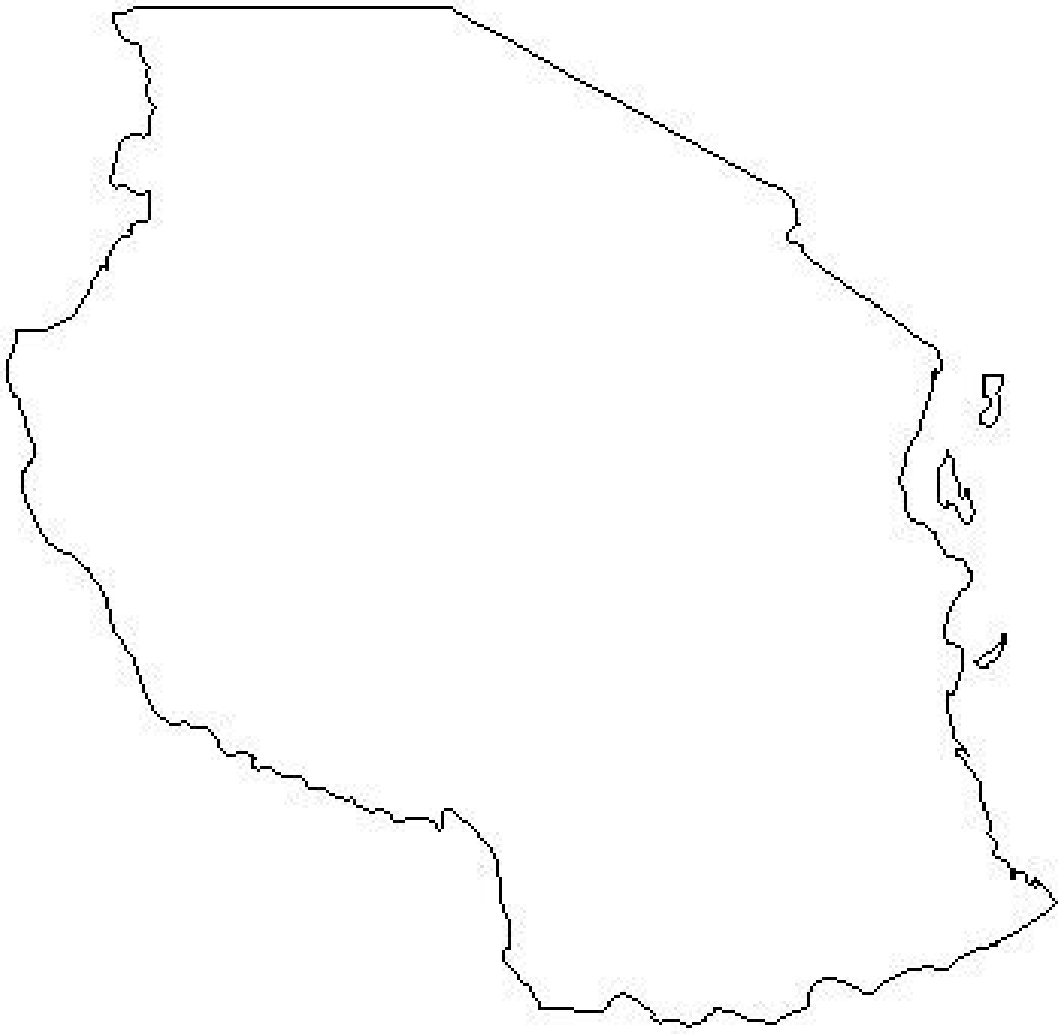
- Were students able to graph temperature data over time for one location in East Africa?
- Were students able to find the line of best fit?
- Were students able to compare the rate of temperature change in the two different ecosystems?
- Were students able to pose scientific questions about the reasons for the different rates of temperature change?
- Were students able to make predictions about the possible effects of temperature change on vegetation, land use, and people's livelihoods?

Web Resources

1. This article deals with the causes of rising temperature which result in climate change. http://www.panda.org/about_our_earth/aboutcc/problems/rising_temperatures/
2. This article addresses climate change in Tanzania. The glaciers of Kilimanjaro have retreated substantially in the last 50 years. http://www.panda.org/about_our_earth/aboutcc/problems/rising_temperatures/hotspot_map/tanzania.cfm
3. This website shows a map of the world's hotspots where temperature is rising. http://www.panda.org/about_our_earth/aboutcc/problems/rising_temperatures/hotspot_map/
4. This site has several pages that deal with temperature and elevation. Item 4 has a graph that quantifies elevation and temperature. There is a hot spot under the graph that shows the trend. This is similar to the graph that is used in the lesson. http://www.windows.ucar.edu/tour/link=/earth/Water/water_cycle.html

Map of Tanzania

Mark the locations of Arusha and Zanzibar



Map of Tanzania

Source: Central Intelligence Agency

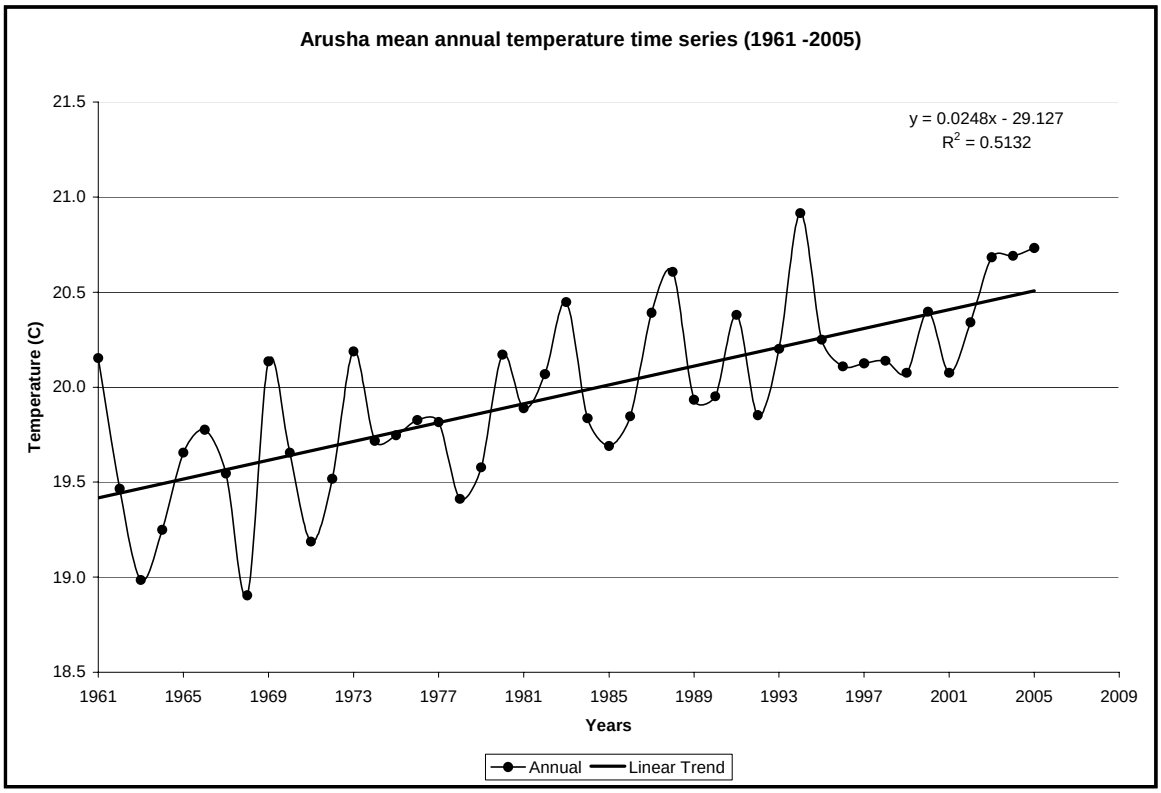
Mean Temperature Data

Arusha Mean Temperature	
Year	Annual mean (°C)
1961	20.2
1962	19.5
1963	19.0
1964	19.2
1965	19.7
1966	19.8
1967	19.5
1968	18.9
1969	20.1
1970	19.7
1971	19.2
1972	19.5
1973	20.2
1974	19.7
1975	19.7
1976	19.8
1977	19.8
1978	19.4
1979	19.6
1980	20.2
1981	19.9
1982	20.1
1983	20.4
1984	19.8
1985	19.7
1986	19.8
1987	20.4
1988	20.6
1989	19.9
1990	20.0
1991	20.4
1992	19.9
1993	20.2
1994	20.9
1995	20.3
1996	20.1
1997	20.1
1998	20.1
1999	20.1
2000	20.4
2001	20.1
2002	20.3
2003	20.7
2004	20.7
2005	20.7

Zanzibar mean Temperature	
Year	Annual mean (°C)
1961	26.0
1962	25.9
1963	25.7
1964	25.1
1965	24.8
1966	23.5
1967	25.3
1968	24.6
1969	24.8
1970	25.7
1971	25.5
1972	25.9
1973	25.6
1974	25.3
1975	26.0
1976	25.5
1977	25.6
1978	26.1
1979	26.3
1980	26.7
1981	26.3
1982	26.5
1983	26.8
1984	26.1
1985	26.0
1986	26.1
1987	27.0
1988	26.5
1989	26.1
1990	26.4
1991	26.5
1992	26.3
1993	26.4
1994	26.5
1995	26.4
1996	26.4
1997	26.6
1998	26.8
1999	26.4
2000	26.5
2001	26.7
2002	26.6
2003	27.4
2004	26.7
2005	27.0

Arusha Mean Annual Temperature Graph

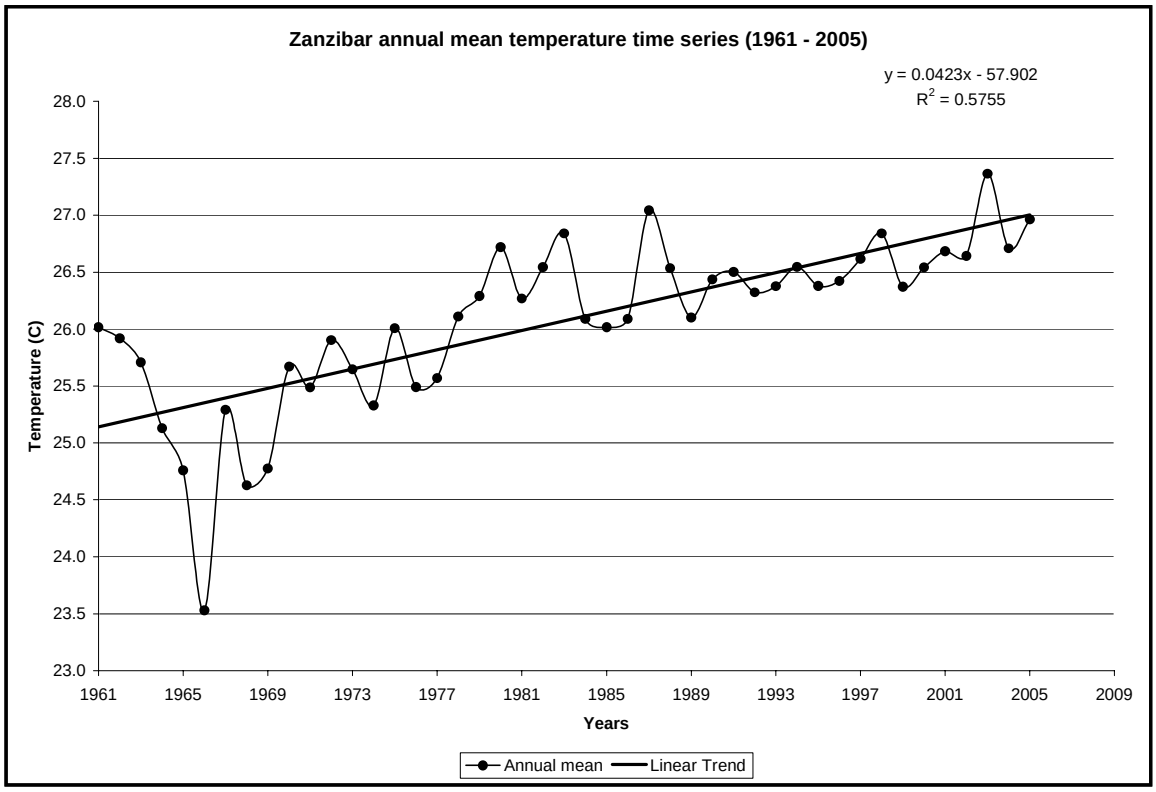
Arusha 1961-2005 (+1.1°C)



Source: Tanzania Meteorological Agency

Zanzibar Mean Annual Temperature Graph

Zanzibar 1961-2005 (+1.9°C)



Source: Tanzania Meteorological Agency

Reflection Questions

Changing Temperatures in East Africa (in degrees Celsius)

Location	Arusha	Zanzibar
Ecosystem		
1961 Average Temp. (from best line of fit)		
2005 Average Temp. (from best line of fit)		
Total Temperature Change		

Reflection Questions

Are temperatures increasing or decreasing in each of the two ecosystems?

Which ecosystem had higher average temperatures in 1961?

Which ecosystem had higher average temperatures in 2005?

Which ecosystem had the greatest increase in temperature?

As a scientist, what question(s) would you pose to find out why there are differences in the rate of temperature change in these two ecosystems?

In the savanna ecosystem, how might increasing temperatures affect vegetation, livelihood systems, and land management? (Refer to the savanna human-land-climate system loop)

If you lived in the East African savanna, what would be your greatest concern about rising temperatures?

Reflection Questions Answers

Changing Temperatures in East Africa (in degrees Celsius)

Location	Arusha	Zanzibar
Ecosystem	Savanna	Coastal
1961 Average Temp. (from best line of fit)	19.4	25.2
2005 Average Temp. (from best line of fit)	20.5	27.1
Total Temperature Change	+1.1	+1.9

Reflection Questions:

Are temperatures increasing or decreasing in each of the two ecosystems?
Increasing in both.
Which ecosystem had higher average temperatures in 1961? Coastal

Which ecosystem had higher average temperatures in 2005? Coastal

Which ecosystem had the greatest increase in temperature? Coastal

As a scientist, what question(s) would you pose to find out why there are differences in the rate of temperature change in these two ecosystems?
Answers will vary, but could include:
What factors contribute to higher rates of temperature increase on the coast?
What factors contribute to slower warming in the savanna?
Does vegetation help slow warming?
Do coastal waters speed warming?
Are there differences in urban development in the savanna and on the coast (urban areas hold heat and could contribute to warming)?

In the savanna ecosystem, how might increasing temperatures affect vegetation, livelihood systems, and land management? (Refer to the savanna human-land-climate system loop)
Answers will vary, but could include:
Species composition could change (less trees and bushes, more grasses).
There could be less ground cover.
There could be less forage for livestock.
Herders could switch to livestock that eat lower quality forage (sheep, goats, camels)
Farmers might have to stop growing maize or grow maize in different locations.
Farmers might have to grow crops that tolerate higher temperatures.
People might have to look for other sources of income, or migrate elsewhere.

If you lived in the East African savanna, what would be your greatest concern about rising temperatures? Answers will vary.