Rainfall in the GLOBE Africa Region: A GLOBE Data Exploration

Purpose

Through explorations of GLOBE rain depth data from Africa, students learn about seasonal patterns in locations affected by monsoons.

Overview

Students analyze GLOBE precipitation data from schools in three countries in Africa as a way of observing monsoon cycles. They learn why monsoons happen and then apply what they have learned to predict which other areas of the world would be affected by monsoon rainfall.

Student Outcomes

Students will be able to:

- Create graphs of GLOBE rainfall data (for the computer-based activity)
- Explain what their graphs indicate about seasonal rainfall in tropical locations in Africa
- Compare graphs and describe how tropical rainfall patterns north of the equator and south of the equator are different
- Explain how monsoon seasonal patterns are caused and predict other locations where a similar pattern of rainfall might be found

Science Concepts

- *Earth Systems Science*
- *Weather and Climate*
- *Weather can be described with quantitative measurements*
- *Weather changes day to day and over seasons.*

Science Practices

- *Asking questions*
- *Analyzing and interpreting data*
- *Constructing explanations*
- *Obtaining, evaluating, and communicating information*

Time

Two class periods (80-100 minutes)

Level

Middle and high school (grades 6-12)

Materials and Tools

For the computer-based activity:

- Computers with access to Microsoft Excel or Google Sheets
- The data file linked with this activity
- *Student Activity Sheet A* (2 pages)

For the pencil and paper activity:

- *Student Activity Sheet* B
- Four *Rainfall Bar Graphs* (pages 11-14)

For both versions:

- *Student Activity Sheets C, D,* and *E*

Preparation

- Bookmark the Web article: *How Monsoons Happen* (monsoon.yale.edu/why-monsoons-happen/)
- Copy *Student Activity Sheets*.
- For the computer-based version, ensure the spreadsheet is loaded on the computers and that the file opens.
- For the pencil and paper version, make enough copies of the four graphs so that each student pair has one.

Prerequisites

Students with some knowledge of the spreadsheet software will be able to accomplish this activity with greater ease than students who are not familiar with the software. If your students are not familiar with the software, you might choose to allow more than two class periods to do this activity and guide the experience for students, or do the pencil and paper version.

Students should have a basic understanding of latitude and Earth's tilt.

Crosswalks to other GLOBE Learning Activities

Consider doing the *How Do Seasonal Temperature Patterns Vary Among Different Parts of the World* Learning Activity or the *Climate and Latitude GLOBE Data Exploration* after this activity to broaden geographic thinking to include other latitudes beyond the tropics.

Background

The seasonal cycle over tropical continents is marked by an oscillation between dry and wet periods brought about by monsoons. A monsoon is not a storm like a hurricane or a summer thunderstorm, but a much larger pattern of winds and rain that spans a large geographic area – a continent or even the entire globe.

The monsoon pattern happens because of oscillations in the Intertropical Convergence Zone (ITCZ), the tropical part of global atmospheric circulation. At the ITCZ, low atmospheric pressure and converging, rising winds cause water vapor to condense, forming clouds and falling as rain. This is where monsoon rainfall occurs.

The ITCZ changes location through the year, which is why monsoon rainfall happens in different months in different parts of the tropics. During December and January, the Southern Hemisphere is heated more strongly by the sun than the Northern Hemisphere, so the hottest air – the air that rises in the ITCZ – is found a little south of the equator. Winds from the Northern Hemisphere blow across the equator towards the ITCZ. During June and July, the Northern Hemisphere is heated more strongly by the Sun, so the ITCZ and its rising hot air lie a little north of the equator and winds blow from the Southern Hemisphere across the equator to reach the ITCZ in the Northern Hemisphere.

The summer monsoon is what people often think of as monsoon conditions: large amounts of rain. But the winter monsoon, where dry conditions prevail, is part of the pattern too. During winter, air descends over tropical continents outside of the ITCZ. Descending air causes high pressure, and makes clouds and rain uncommon. The dry conditions during winter can even lead to drought if they are intense and persist.

During Northern Hemisphere summer, the ITCZ is north of the equator and monsoon rains fall in India and other parts of south Asia as well as northwest African countries, while northern Australia and southern Africa experience drier conditions as air descends.

About the data: The rainfall data used in this activity comes from four GLOBE schools in Africa (see map on *Activity Sheet C*). In the GLOBE data, rainfall is listed as "rain depth." For more information about GLOBE Africa, visit http://www.globe-africa.org/.

Two locations are south of the Equator in Madagascar have rainfall patterns that follow a Southern Hemisphere monsoon pattern with heaviest rainfall happening in December, January, and February. (Note that there is rain at other times of the year in this moist climate, but it is less heavy.)

- Lycee Jean Laborde: precipitation 2004-2008
- Lycee Miandrivazo: precipitation 2005-2008

Two locations are north of the Equator (in Benin and Cameroon) and both follow a Northern Hemisphere monsoon pattern with the heaviest rainfall happening in June, July, and August.

- GBHS Ndop, Cameroon: precipitation 2001-2010
- CEG Bassila, Benin: precipitation 2003-2007

The data used in the assessment comes from the Center for Environment Education in Ahmedabad, India.

What To Do and How To Do It

Step 1. Engage students with the concept of monsoons and survey prior understanding.

- Ask students to say the first thing that comes to mind when they hear the word 'monsoon.' Record answers on the board. Have students think individually about what conditions cause monsoon rains, then share their thoughts with a partner, and choose one idea to share with the whole class (the "Think, Pair, Share" strategy).

- Explain that students in many countries in Africa have been making measurements of rainfall each day for many years. If students are not familiar with how precipitation is measured, show them a picture of a rain gauge and explain how the amount of rain is measured.
- Tell students that in this activity they will explore rainfall data collected at schools in Cameroon, Benin, and Madagascar to learn how seasons affect monsoon rain.

Step 2. Orient students to the African rainfall data. (computer-based version)

- *Note: If you are doing the pencil and paper version of this activity, proceed to Step 5.*
- Assign each pair a computer and one of the four locations in Africa to investigate (Benin, Cameroon, Madagascar West, or Madagascar East). Each student will need *Student Activity Sheet A* (2 pages).
- Have each pair open the spreadsheet and click on the tab (at the bottom of their screen) to see the data for their assigned location.
- Review the headings on the data table. The left column is the date and time when a measurement of rain depth was taken. The right column is the amount of rainfall measured. Tell students that GLOBE students in Africa take measurements of rain depth using a rain gauge. In this case, rainfall is measured in millimeters each day.

Step 3. Students use descriptive statistics to describe rainfall amounts for one location.

- Following the directions on *Student Activity Sheet A*, student groups will calculate the average rainfall for their location, the average rainfall during December, and the average rainfall for July. Students are asked to make observations based on their calculations.

Step 4. Students create a bar graph of rainfall patterns for one location.

- Following the directions on *Student Activity Sheet A*, have student groups make a graph to examine how precipitation varies over time.
- *Skip ahead to Step 6.*

Step 5. Orient students to the graphs of rainfall data. (pencil-and-paper version)

- Hand out *Student Activity Sheet B* to each student and one of the four graphs to each pair of students. Instruct students to interpret the graph of rainfall data using *Student Activity Sheet B* as a guide.

Step 6. Have students share information about their location's rainfall with student groups that have other locations.

- Have pairs join with pairs that had the other three locations so that they can share information about rainfall in all four locations in Africa. Hand out *Student Activity Sheet C* and instruct students to to take notes on about rainfall patterns in different locations in Africa. Students should recognize that Benin and Cameroon have one pattern and the two Madagascar locations have an opposite pattern of rainfall through the year.

Step 5. Class discussion and presentation

- Ask students what they noticed. Does rainfall follow a pattern through the year at your location? Does rainfall follow the same pattern in all four locations in Africa? Which places have similar pattern? Guide students to consider the location of each country with respect to the equator. Ask questions similar to the following:
  - Why do you think the patterns are different in each location?
  - What previous concept connects to this pattern?
  - How does this data impact your understanding of monsoons?
  - What questions do you have?

Step 6. Students learn the science of why these patterns occur.

- Tell students that the rainfall patterns they saw and explored are due to monsoon cycles which happen in the tropics. Have students read the article *Why Monsoons Happen* on the World Monsoons web site.

- Have students complete the graphic organizer on *Student Activity Sheet D* and then explain what they learned and how this relates to the rainfall patterns that they explored in the GLOBE data.

Assessment

- Hand out *Activity Sheet E*. The graph on this sheet shows GLOBE rainfall data collected in India. On this activity sheet, students are asked to apply what they learned about monsoon patterns in the northern and southern hemispheres to another area of the world.

Extensions: Delve Deeper into GLOBE Data

Have students explore their seasonal pattern of rainfall by collecting GLOBE precipitation data following the GLOBE Precipitation Protocol.

Extend student learning with the Learning Activities, videos, and water cycle resources on GLOBE Global Precipitation Measurement Resources page.

Challenge students to analyze data collected by others using the GLOBE Advanced Data Access Tool or the GLOBE Visualization Tool.

Explore seasonal variations in the hydrosphere with GLOBE data about waterways (in particular those that are in monsoon regions). Have students make hypotheses about how waterways would change due to monsoon rainfall.

Investigate how temperature varies in the same locations explored through this activity. Have students predict how temperature would vary through the year.

Compare GLOBE rainfall data collected in African countries with precipitation measurements made from space with NASA's Global Precipitation Measurement (GPM). The most recent GPM data can be viewed in Google Earth http://pmm.nasa.gov/data-access/google-earth.

Credits

This activity is part of *GLOBE Data Explorations*, a collection of activities developed by the UCAR Center for Science Education (scied.ucar.edu), a GLOBE partner. Activities were reviewed by science educators and staff at GIO and field tested by teachers.

Name _____

Date _____

The data in this activity are rainfall measurements from Africa. Different groups in the class are exploring data from different locations. Completed your data analysis using this student instruction sheet as a guide.

Step 1. About the data
Take a look at the spreadsheet that was assigned to your group and note the following:

Where was the data collected? _____

Over what timeframe was the data collected?

Start date: _____

End date: _____

What are the units of measurement used for rain depth?

_____

Was a measurement made everyday? _____
If not, do you see big gaps in the data (a week or more)?

_____

Step 2. Get to know the data.
Descriptive statistics are used to get a sense of a set of data. They can help you summarize data and make a first description of the data. In this part of the lesson you will measure the average (or mean) of all the rain depths and then compare different months of data.

How much rain falls each day, on average, according to these data? _____

How much does it rain in December, on average?

_____

How much does it rain in July, on average? _____

What do you observe based on these calculations?

What else would you like to know?

To calculate an average
(using spreadsheet software)

1. Click on a cell of the spreadsheet that is empty and outside the area with the data.

2. Type **=AVERAGE(** into the cell.

3. Select all the data in the "rain depth" column by clicking on the first cell of data and then dragging down to select all cells below it. (This will indicate which data to average in the formula.)

4. Go back to the cell with the formula and you will see something like **= AVERAGE(B7:B208**.

5. Add a **)** to the end of the formula and hit the return key. The average of the data you selected should appear in the cell.

Instructions created for MS Excel 14.4.4 and 2015 Google Sheets.

Step 3. Explore seasonal patterns.
A graph makes data visual, which can make patterns more obvious. Make a bar graph of rainfall patterns for the location your group was assigned to see how rainfall varied over time at this location in Africa. (See the directions for making a bar graph at the right.)

What months look like they have the most rainfall according to your graph?

What months look like they have the least rainfall according to your graph?

Is a similar pattern of rain visible in each year that data was collected?

Is there always the same amount of rain each year in this location?

What else do you observe in this graph?

What else would you like to know?

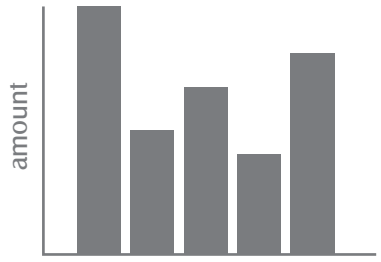
To make a bar graph
(using spreadsheet software)

1. Select the "Measured at" and "Rain depth" data and headings by clicking and dragging over all the cells.

2. Click on "charts" in the options above the spreadsheet (or "insert chart" in Google Sheets).

3. Select "column" or "clustered column," and a bar graph will appear with millimeters of rain on the y-axis and date on the x-axis.

(Note: Specific chart types vary in different versions of Microsoft Excel and Google Sheets. Refer to your program's help information if you need detailed information about making charts.)



A bar graph (which is also called a bar chart) is useful for comparing how amounts vary. In this case, you are looking at how the amount of rain varies over time.

Instructions created for MS Excel 14.4.4 and 2015 Google Sheets.

Exploring Monsoon Rains
Student Activity Sheet B

Name _____

Date _____

The data in this activity are rainfall measurements from Africa. Different groups in the class are exploring graphs of rainfall data from different locations. Analyze the data in your graph ousing this worksheet as a guide.

Step 1. About the data
Take a look at the bar graph and note the following:

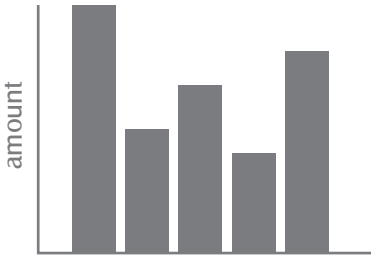
Where was the data collected? _____

Over what timeframe was the data collected?

Start date: _____

End date: _____

What are the units of measurement used for rain depth? _____



A bar graph (which is also called a bar chart) is useful for comparing how amounts vary. In this case, you are looking at how the amount of rain varies over time.

Step 2. Explore seasonal patterns.
A graph makes data visual, which can make patterns more obvious. Take a look at the bar graph of rainfall patterns for the location your group was assigned to see how rainfall varied over time at this location in Africa.

What months look like they have the most rainfall according to your graph?

What months look like they have the least rainfall according to your graph?

Is a similar pattern of rain visible in each year that data was collected?

Is there always the same amount of rain each year in this location?

What else do you observe in this graph?

What else would you like to know?

Exploring Monsoon Rains
Student Activity Sheet C

Name _____

Date _____

Consider rainfall data geographically.
Take notes on the map below to summarize what you learn about rainfall patterns in other parts of Africa and how they compare to your location.

Benin

The most rainy months of the year:

The least rainy months of the year:

Cameroon

The most rainy months of the year:

The least rainy months of the year:

Madagascar West

The most rainy months of the year:

The least rainy months of the year:

Madagascar East

The most rainy months of the year:

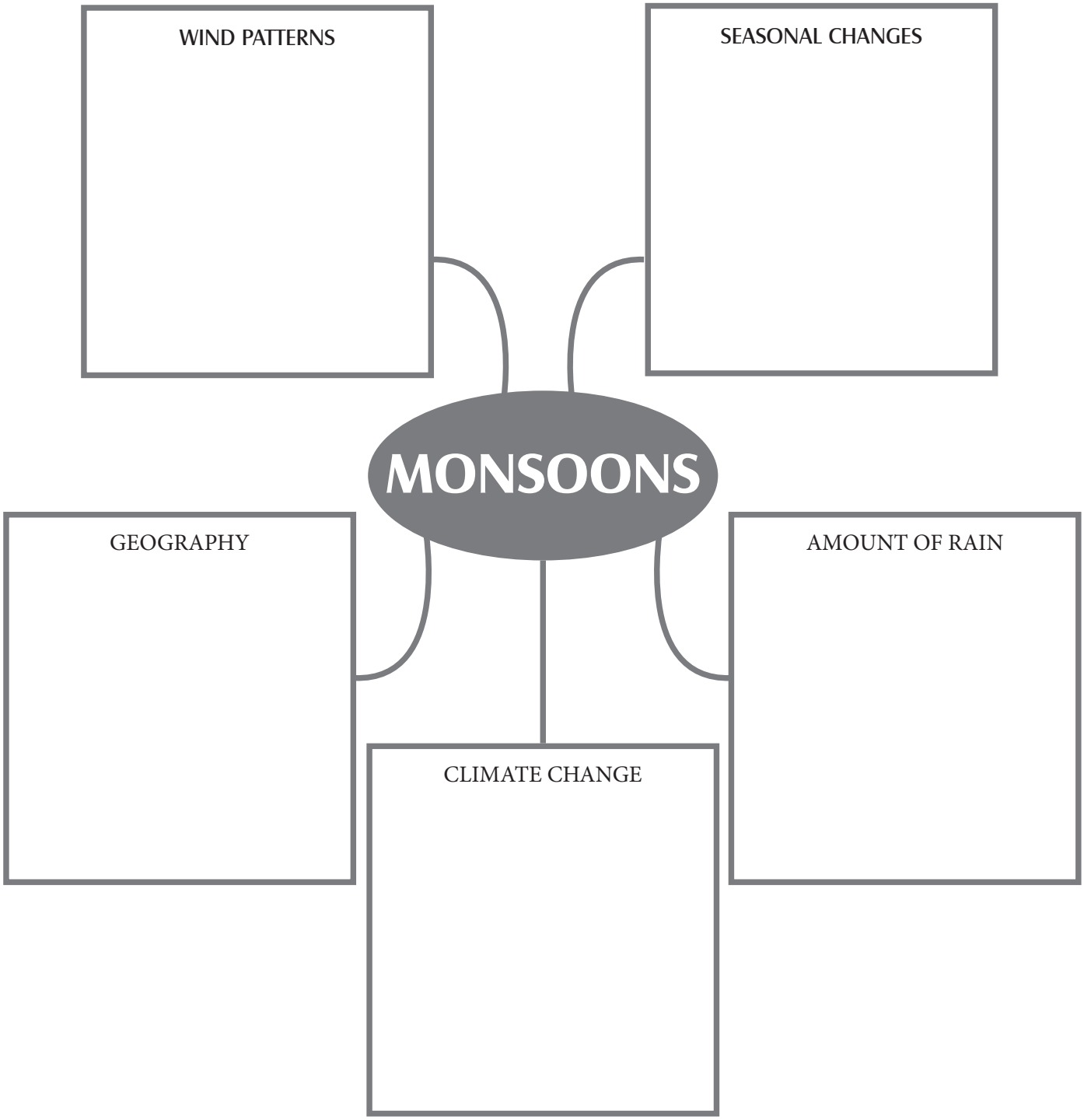
The least rainy months of the year:

Exploring Monsoon Rains
Student Activity Sheet D

Name _____

Date _____

Make a graphic organizer to describe what you learn from the online reading.
Graphic organizers provide a visual representation of ideas from a reading to help you see relationships among ideas and show how concepts link together. As you read the *Why Monsoons Happen* web article, add important information from the reading into the boxes of the following graphic or create one on your own on another piece of paper.

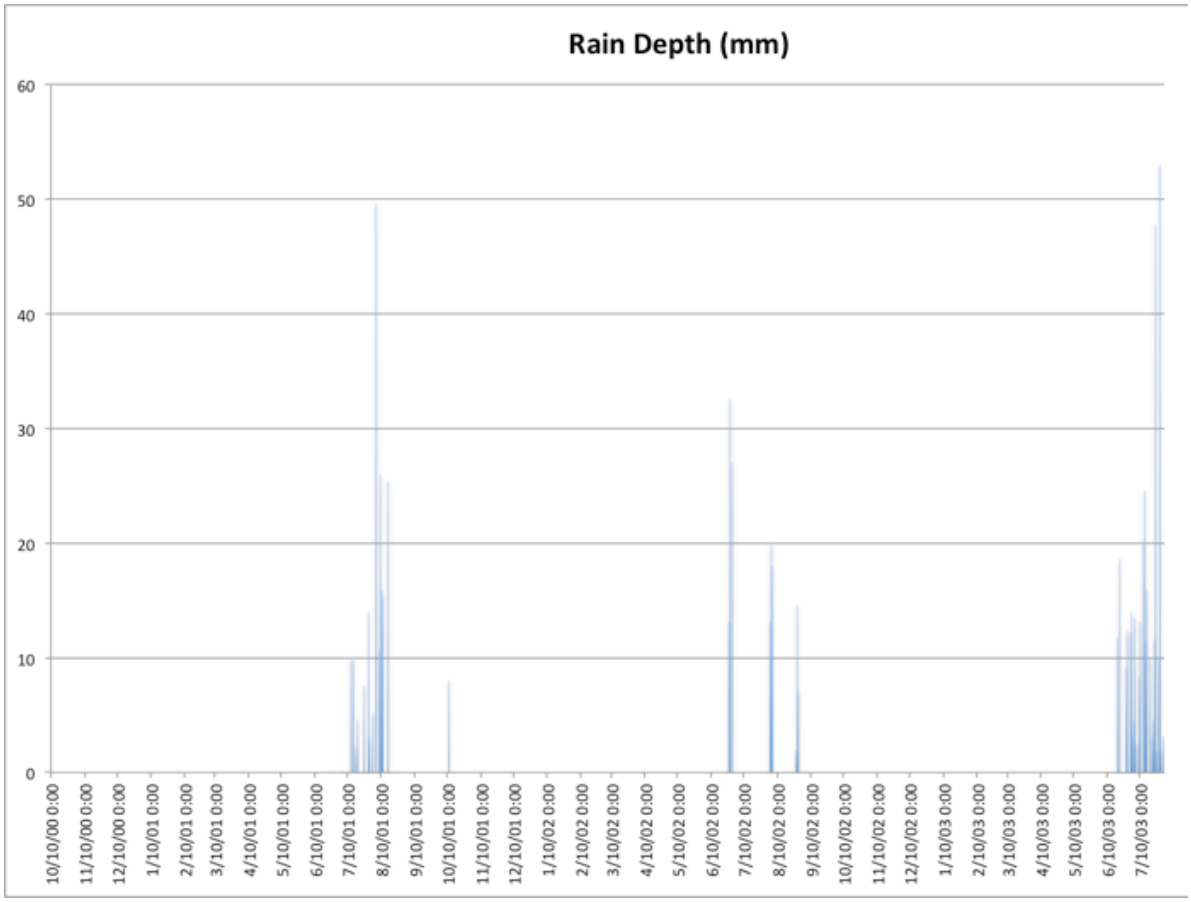


Name _____

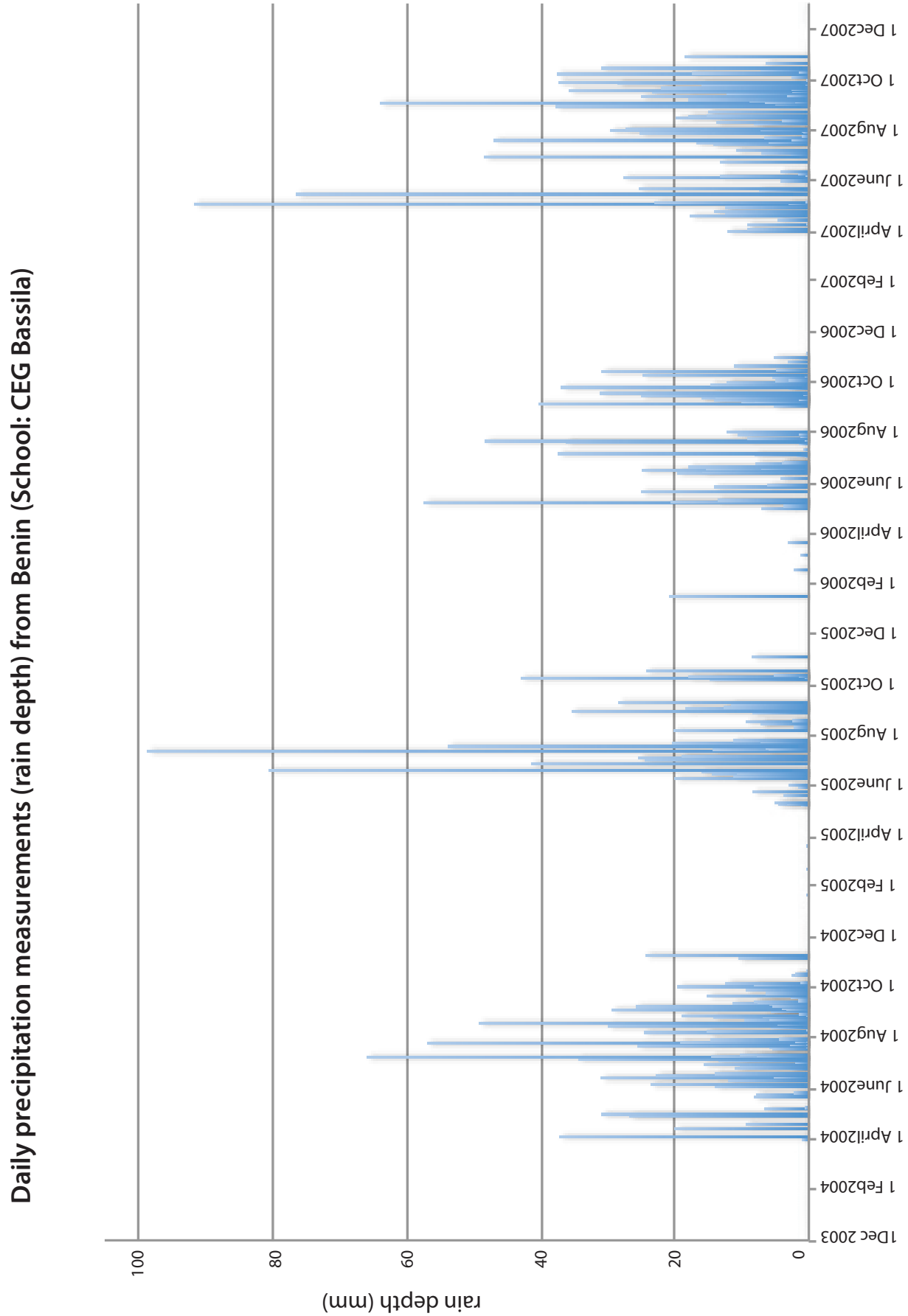
Date _____

Assessment: Apply what you've learned.

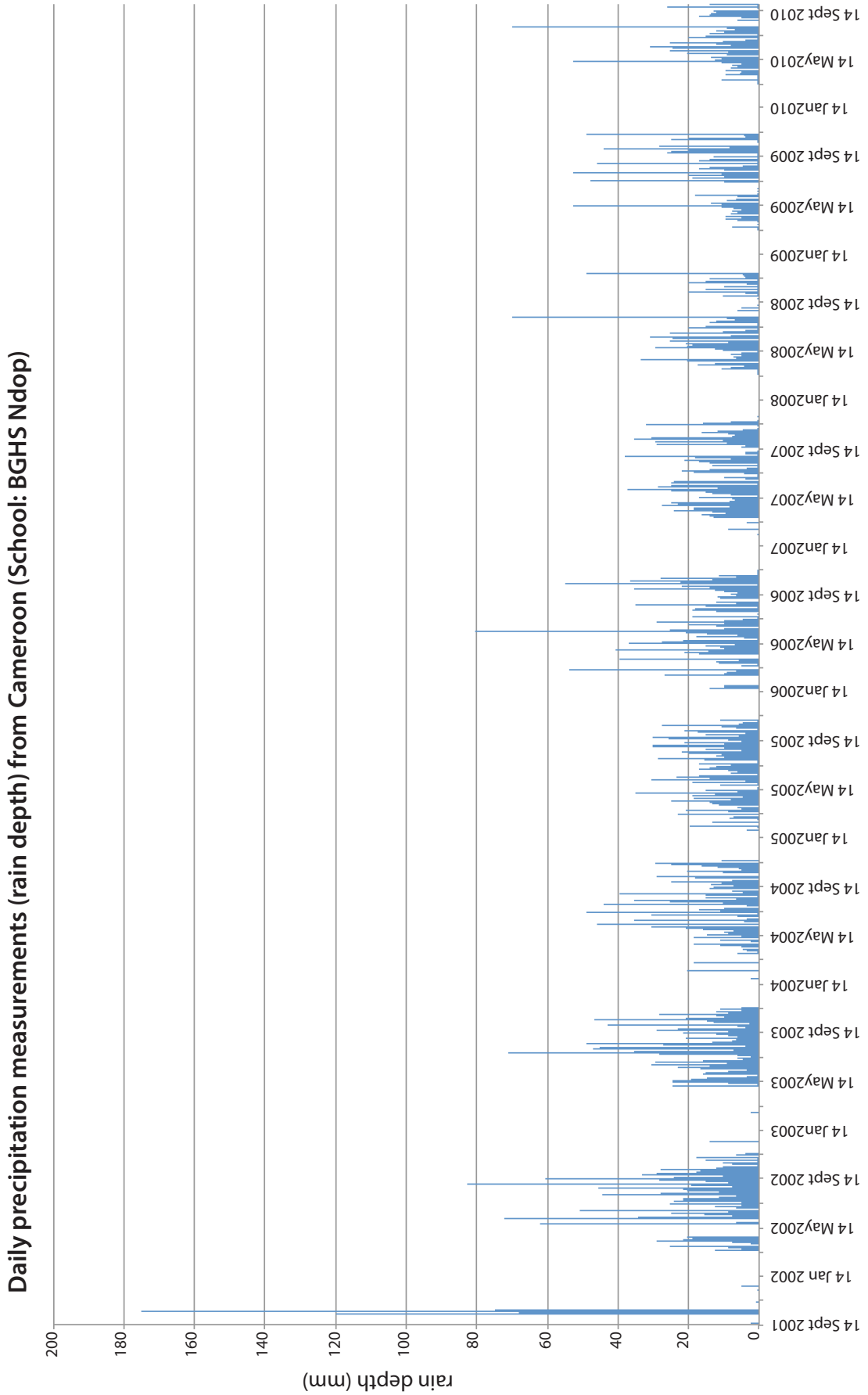
The graph below is made with GLOBE rainfall data from an environmental education center in Ahmedabad, India. Note whether you see a monsoon seasonal pattern in the rainfall. Describe the pattern below. When is rain most likely? Least likely? Does this pattern resemble one or more of the African rainfall patterns?



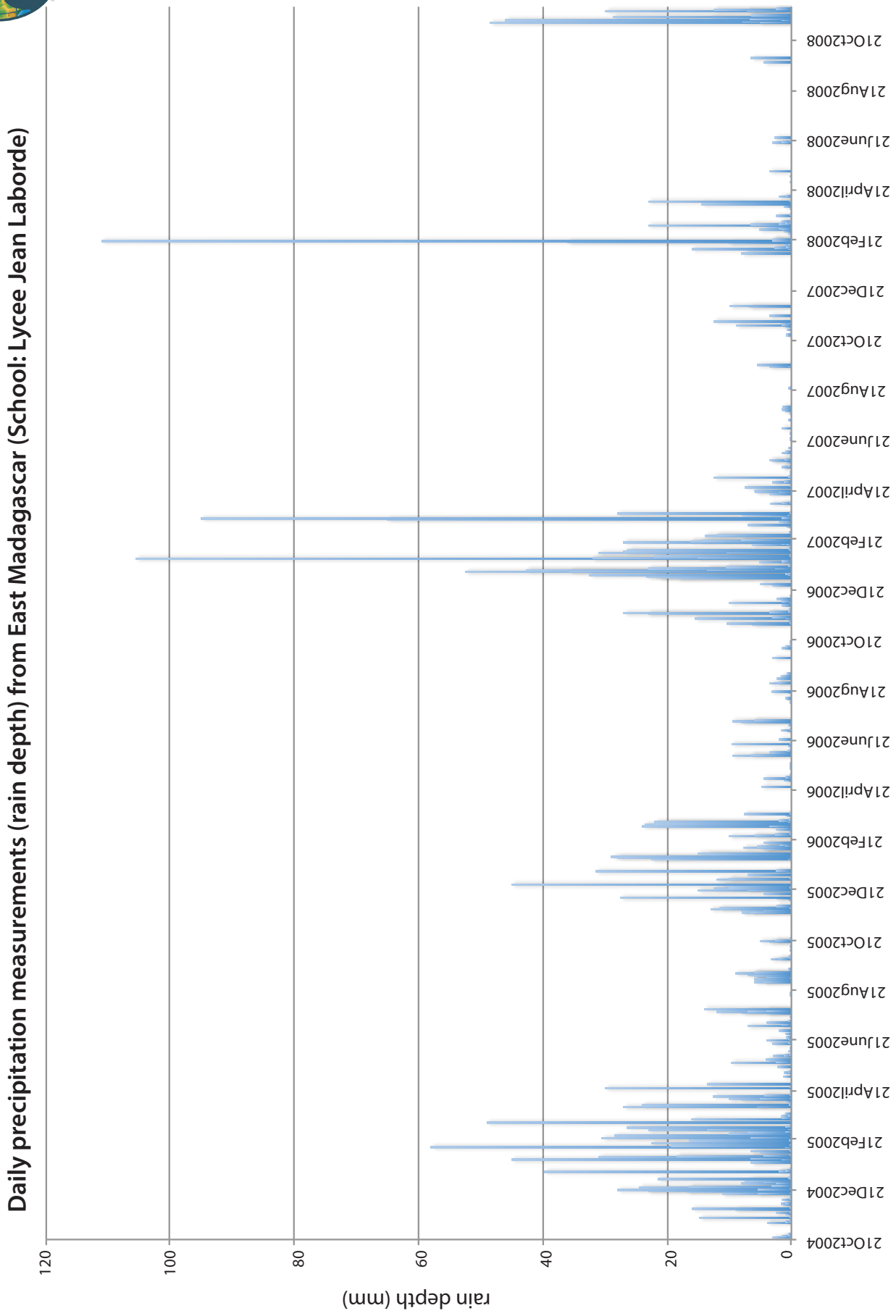
Take a look at a map of the world. Locate India and then consider where you would look to find a rainfall pattern that is opposite what you see in the India data. Explain why you would look in this place (or these places).


Daily precipitation measurements (rain depth) from Benin (School: CEG Bassila)
rain depth (mm)
0
20
40
60
80
100
1Dec 2003
1 Feb2004
1 April2004
1 June2004
1 Aug2004
1 Oct2004
1 Dec2004
1 Feb2005
1 April2005
1 June2005
1 Aug2005
1 Oct2005
1 Dec2005
1 Feb2006
1 April2006
1 June2006
1 Aug2006
1 Oct2006
1 Dec2006
1 Feb2007
1 April2007
1 June2007
1 Aug2007
1 Oct2007
1 Dec2007

Rainfall in the GLOBE Africa Region
Rainfall Bar Graph: Cameroon



Rainfall in the GLOBE Africa Region
Rainfall Bar Graph: East Madagascar



Rainfall in the GLOBE Africa Region
Rainfall Bar Graph: West Madagascar