Hurricane & Storm Frequency Over Time

Materials

For the leader:

Projector

Whiteboard to project data graph onto

For the activity:

Copy of 1878-2007 North Atlantic Storm Counts data table

Computer program to graph in or graphing paper

Copy of student worksheet

Overview

There has been an increase in the average number of storms per year in the North Atlantic Ocean since the late-1980s. However, to determine if climate change is influencing hurricane and short-duration storm (< 2 days) frequencies, it is important to look at a longer time series (> 100 yr) of storm activity. Data demonstrates that there has been a century scale increase in global and tropical Atlantic Sea Surface Temperatures (SST) since the late 1800s. If climate change and increased SST was causing an increase in storm frequency, then we would hypothesize that there would also be long-term increasing pattern in Atlantic storm frequency for both hurricanes and short-duration storms.

In this activity, students will look at both hurricane and short-duration storm frequency data for the North Atlantic Ocean over time. The activity places a strong emphasis on teaching students how to interpret data. The students first need to plot the two data sources and then interpret it for conclusions. Through a series of questions, students are lead in their exploration and investigation of the data to think about how the time frame over which the data is collected dataset can influence what conclusions you draw from the data. In addition, students will think through alternative options to climate change to explain the observed patterns in the data. Students will observe that there is no overall pattern of increased frequency of hurricanes in the North Atlantic Ocean over the past century but that there is an increase in the frequency of short-duration storms most likely due to better reporting abilities. In using these data interpretation skills, students will gain a better understanding of how scientists look at evidence when asking questions about changes in the Earth's climate and extreme weather events over time.

Motivating Questions: **What evidence do scientists use to study storm frequency over time? Are changes in storm frequency related to climate changes?**

Take Home Message

Scientists collect data from multiple sources to track storms over time. However, it is important to understand how those sources of data can influence the conclusions you draw from the data and that the time frame in which you look at the data can influence your conclusions.

Engage: Lead the students in a discussion about what they know about tropical storms and hurricanes and how we could determine if climate change is influencing storm frequency.	10 minutes
Explore: Students investigate data of the hurricane and short-duration storm frequencies for the North Atlantic Ocean over the past century.	25 minutes
Make Sense: Students share their observations, ask questions, and discuss what they can learn from the storm frequency graph.	10 minutes
Total:	**45 minutes**

Audience

High school students (9th-12th grade).

New Jersey Core Curriculum Content Standards - Science

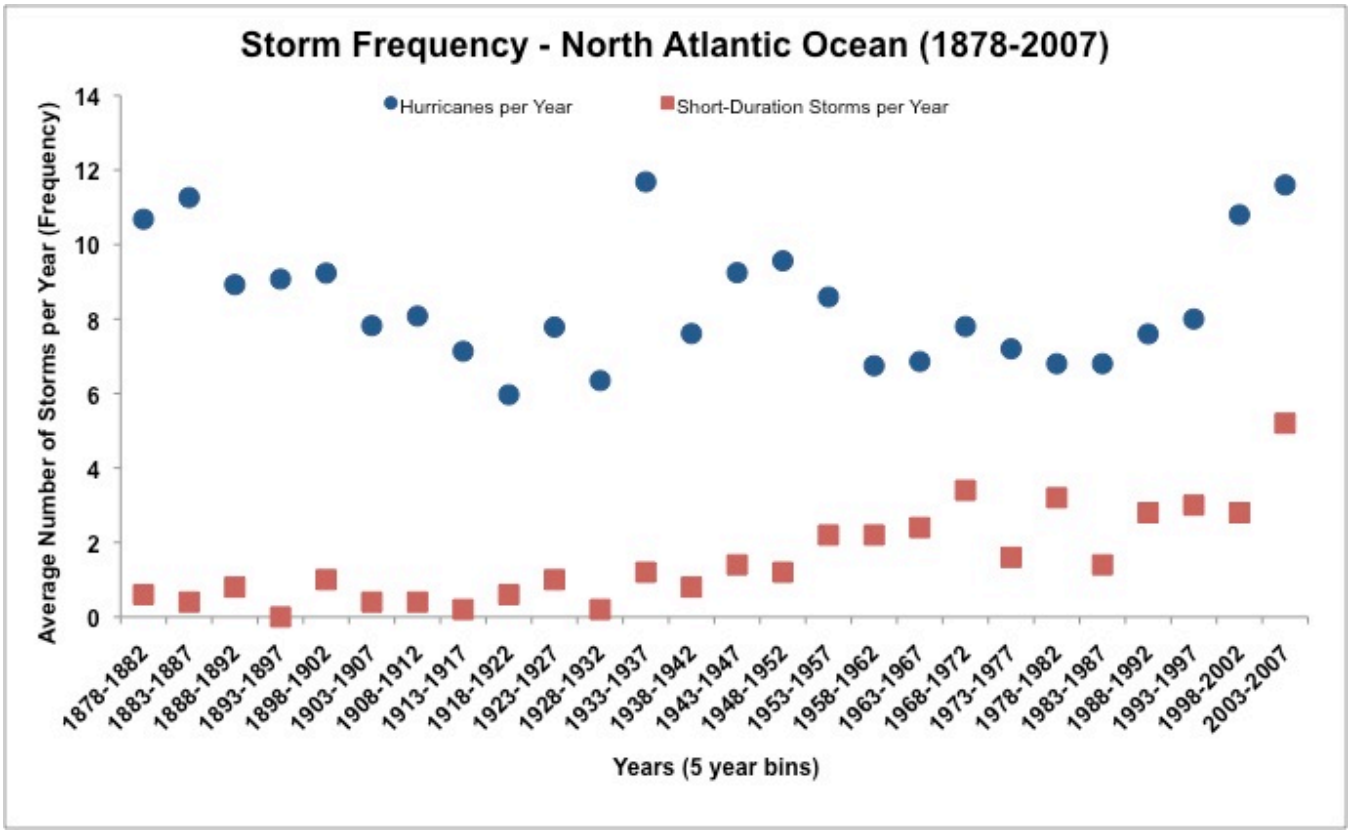
Grade	Content Statement	CPI#
12	Climate is determined by energy transfer from the Sun at and near Earth's surface.	5.4.12.F.2
12	Human activities have changed Earth's land, oceans, and atmosphere, as well as its populations of plant and animal species.	5.4.12.G.5
12	Mathematical tools and technology are used to gather, analyze, and communicate results.	5.1.12.B.2
12	Empirical evidence is used to construct and depend arguments.	5.1.12.B.3
8	Scientific reasoning is used to evaluate and interpret data patterns and scientific conclusions.	5.1.12.B.4
12	Science involves practicing productive social interactions with peers, such as partner talk, whole-group discussions, and small-group work.	5.1.12.D.1

Preparation (20 minutes)

1. Write the motivating questions on the board:

   What evidence do scientists use to study storm frequency over time? Are changes in storm frequency related to climate change?

2. Make copies of student worksheets, one for each student (at the end of this write-up).
3. Make or project a graph of the data on the board, but make sure it is hidden from the students.



Engage (10 minutes)

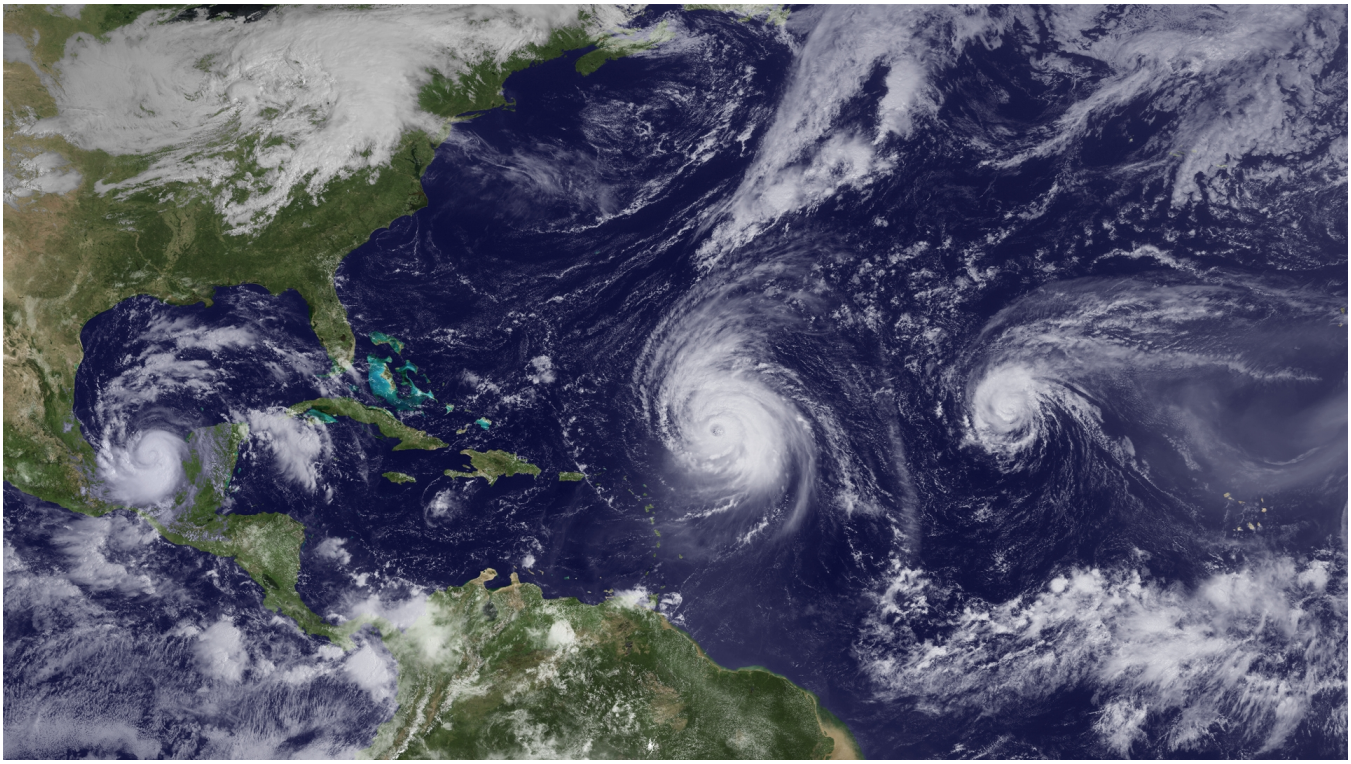
1. Project the Hurricanes Across the Atlantic image (below) and lead the students in a discussion using the following questions about what they know about tropical storms, hurricanes, and climate change. Be accepting of all answers, as this is a group brainstorming activity.

Q. What is a hurricane? Where do they occur? When do they occur?

Q. What is a tropical storm, or short-duration storm?

Q. Why do scientists study hurricanes and tropical storms?

Q. Why would scientists be interested in understanding changes in the number of storms over time in the North Atlantic Ocean?



2. After a few minutes, and depending on what the students already know, share some information with them that you feel they need to know to understand the activity of the day.
3. Ask the students what they have heard about the relationship between climate change and tropical storms/hurricanes. Some students might suggest that climate change is increasing the number of hurricanes in the world (if this does not come up, it's ok, continue to the next step).
4. Ask the students what they would need to look for to determine if there is an influence of climate change on storm frequency. Also ask over what time scales should we consider when determining if there is an influence of climate change on the number of storms per year.
5. Have the students come up with hypotheses about the relationship between climate change and the average number of storms per year. Ask the students to think about the following question and articulate their hypotheses, while you record them on the board.

Q. What pattern do we expect to see in the number of storms (hurricanes and short-duration storms) in a year if climate change is influencing hurricane frequency?

Explore (25 minutes)

1. Explain to the students that they will be taking a closer look at storm frequency in the North Atlantic Ocean over the past century. In fact, they will be making their own plots of the average number of hurricanes per year and the average number of short-duration storms per year to look for patterns in the dataset.
2. Explain the data processing portion of the investigation to the students:
    a. In a few moments they will receive a data table of the average number of storms per year, in 5-year time spans, in the North Atlantic Ocean from 1878 to 2007.
    b. First, they need to look at the data to check for outliers within both fields of data (hurricanes and short-duration storms), this is called data processing. They can do this either by reading through the data table or by plotting the data and looking for values that are very different than the others (by an order of magnitude).

       ** Note – there are no outliers in this dataset, but this is to get the students familiar with checking their data before analyzing it.
    c. If they find data points that are not actual data points, the students should decide what they want to do about those data points. Do they throw them out? Do they make them zero? Let them discuss this in small groups.
3. If your students are confused by the average number of storms per year for a 5-year time span, then make sure to explain how the data were calculated. For example, the numbers of hurricanes for each year in the time span from 1878 through 1882 collected were: 14, 10, 13, 9, and 6. The average of these annual values then was calculated to determine the "average number of hurricanes per year" for that 5-year time span. This process was repeated for each time span within the dataset and for the short-duration storms data.
4. Ask the students if they have any questions about the data processing portion of the activity. Did they find any outliers in the dataset? Call on different students or student groups to share their opinions of whether or not they found outlier data. Allow them to discuss this for a few minutes but stress that they do NOT need to come to a consensus as a class. Every scientist is faced with this decision and each makes his/her own choice of how to proceed.
5. Explain the data plotting and interpretation portion of the investigation:
    a. Once they have processed the data and are comfortable that all of the data in the data table are actual data points, they should first plot the average number of hurricanes per year for the North Atlantic Ocean from 1878-2007.
    b. Ask the students:
        i. What kind of graph will we use? (Marked Line)
        ii. What is the x-axis? (Years)
        iii. What is on the y-axis? (Average Number of Storms Per Year (Frequency))
        iv. In the graph do we connect the data points from each year? (No, because the average number of hurricanes per year for the 5 years is a discrete variable.)

c. Have the students look at the hurricane data to find patterns in the average number of hurricanes per year in the North Atlantic Ocean by completing the student worksheet.

d. Then have the students plot the average number of short-duration storms per year for the North Atlantic Ocean 1878-2007.

e. Have the students look at the short-duration storm data to find patterns in the average number of short-duration storms in the North Atlantic Ocean by completing the student worksheet.

6. As the students finish their graphs and answering the questions on the student worksheet, ask them to write a written response to:

Q. What patterns can you observe in the data? Is there a pattern between the number of hurricanes and time? If so, what is the pattern?

Q. Is there a pattern between the number of short-duration storms and time? If so, what is the pattern?

Q. Based upon your hypotheses and these data, do you think that climate change is influencing the number of hurricanes over time? Do you think climate change is influencing the number of short-duration storms over time?

Make Sense (10 minutes)

1. After a few minutes of writing their responses, tell the students that we are going to interpret and analyze the data as a class.
2. Have the students report out what patterns they observed in the data over different time scales in the dataset. Make sure to have the students support their statements of the patterns by stating what evidence they are using.
    a. Help the students see that the pattern in average number of hurricanes per year is variable over time, but that overall the number of hurricanes has not changed over the course of the past century. However, the observed pattern in number of hurricanes varies depending on what time scale you look at in the dataset: e.g., decreases from 1883 to 1922, stays the same from 1923 to 1972, and increases from 1983 to 2007.
    b. Help the students see that there is an overall increase in the average number of short-duration storms per year over the past century.
3. Lead the students in a discussion about these differences in observed patterns of the average number of storms per year data. Some discussion points you might want to hit on:
    a. Help the students think about how it is important to understand where the data is coming from when looking at any dataset, especially a time series back in time. For example, when looking at the short-duration storm data the marked increase in the number of short-duration storms around 1950s-60s coincides with the rapid increase in the amount of technology that we use to observe storms around the globe. If you did not think about how the data were collected, you could interpret the increase in short-duration storms to mean that climate change is increasing the numbers of these storms per year. However, when you think about the data collection techniques and the potential physical processes through which climate change could influence short-

duration storm formation it becomes evident that this is a sampling bias rather than an actual phenomenon.

b. Help the students think about how the time frame that you use to talk about patterns in the number of hurricanes has a large influence on your conclusions of what the pattern in the data is.
    i. What does that mean for making conclusions about data? – It is extremely important to know the time frame over which you would expect to see the phenomenon you are interested and determine if your data is longer than that time frame, in order for you to see the pattern.
    ii. What time frame should we look at if we are interested in yearly or decadal patterns? – Yearly patterns can be observed by comparing data from different consecutive years. Decadal patterns can be observed by comparing data from different consecutive decades.
    iii. What time frame should we look at if we are interested in the potential influence of climate change? – There is no correct answer to this question, however the current impacts of climate change have been observed over multiple decades so having a longer time series of data than that would be at least a good place to start.
c. Help the students think about how if we are only looking at year-to-year or decade-to-decade variation in the number of hurricanes (as many talk about with the large number of hurricanes that have made landfall in the past few years) we will miss the larger patterns over time (aka those that could be influenced by climate change).

4. Once the discussion slows down, point to the motivating questions and ask the students to share their ideas about the following questions with a partner:
Q. What evidence do scientists use to study storm frequency over time? Are changes in storm frequency related to climate changes?
5. After a minute, ask volunteers to share the ideas they discussed with the entire class. Be accepting of all responses from the students. This is your opportunity to make sure the students understand the "take home message."
6. Ask if the students have any final questions about the activity, data processing/graphing, or relationship between the number of hurricanes and climate change.

Hurricane & Storm Frequency Over Time Worksheet

Name: _____ Date: _____

Hurricane Data Interpretation Questions:

1. What is the pattern in the number of hurricanes data from 1878 to 2007?

2. What is the pattern in the number of hurricanes data from 1983 to 2007?

3. What is the pattern in the number of hurricanes data from 1883 to 1922?

4. What is the pattern in the number of hurricanes data from 1923 to 1972?

Short-Duration Storm Data Interpretation Questions:

1. What is the pattern in the number of short-duration storms data from 1878 to 2007?

2. What is the pattern in the number of short-duration storms data from 1983 to 2007?

3. What is the pattern in the number of short-duration storms data from 1883 to 1922?

4. What is the pattern in the number of short-duration storms data from 1923 to 1972?

Writing Prompts:
What patterns can you observe in the data? Is there a pattern between the number of hurricanes and time? If so, what is the pattern?

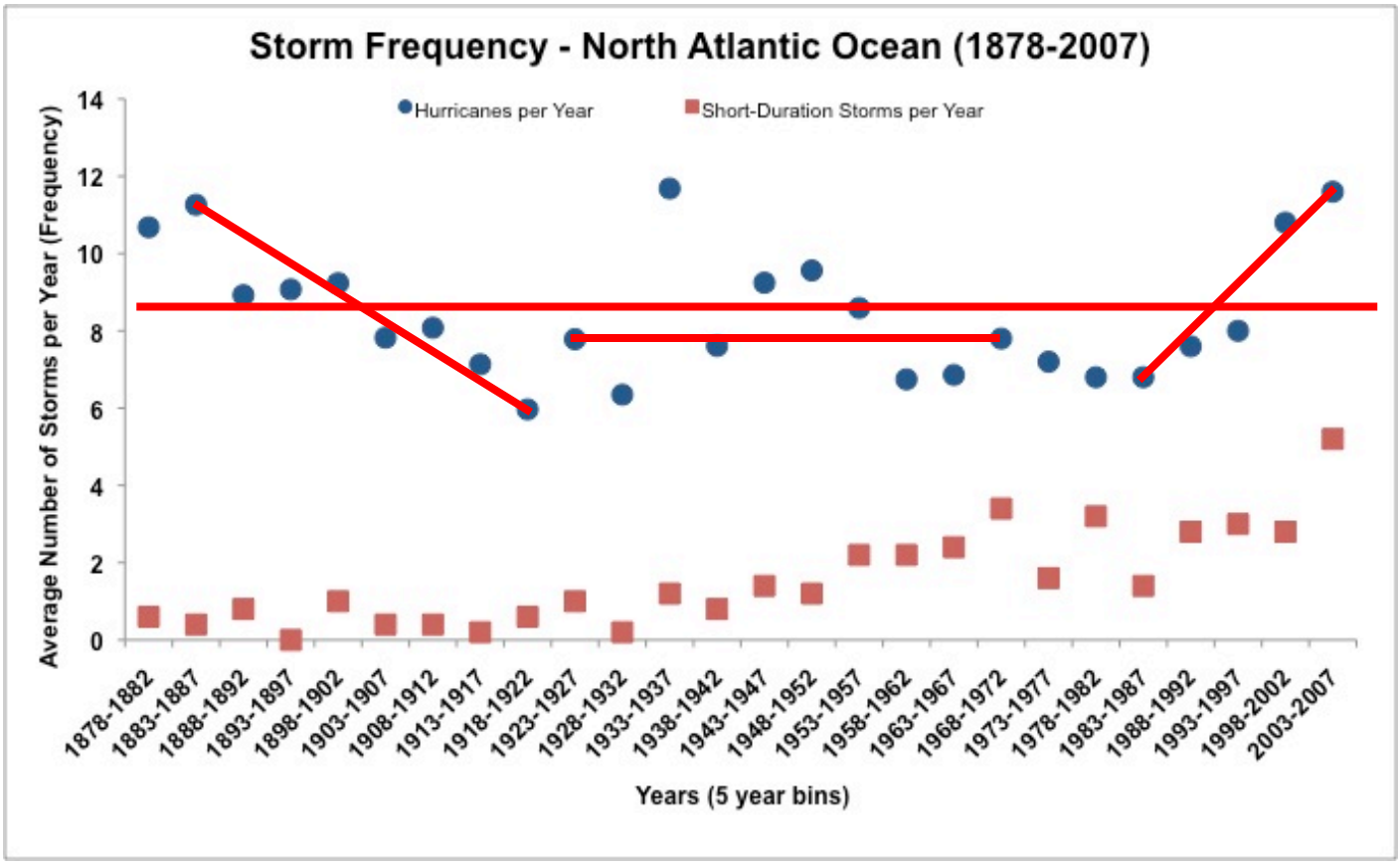
Is there a pattern between the number of short-duration storms and time? If so, what is the pattern?

Based upon your hypotheses and these data, do you think that climate change is influencing the number of hurricanes over time?

Do you think climate change is influencing the number of short-duration storms over time?

Hurricane & Storm Frequency Over Time – Answer Key

Name: _____ **Date:** _____



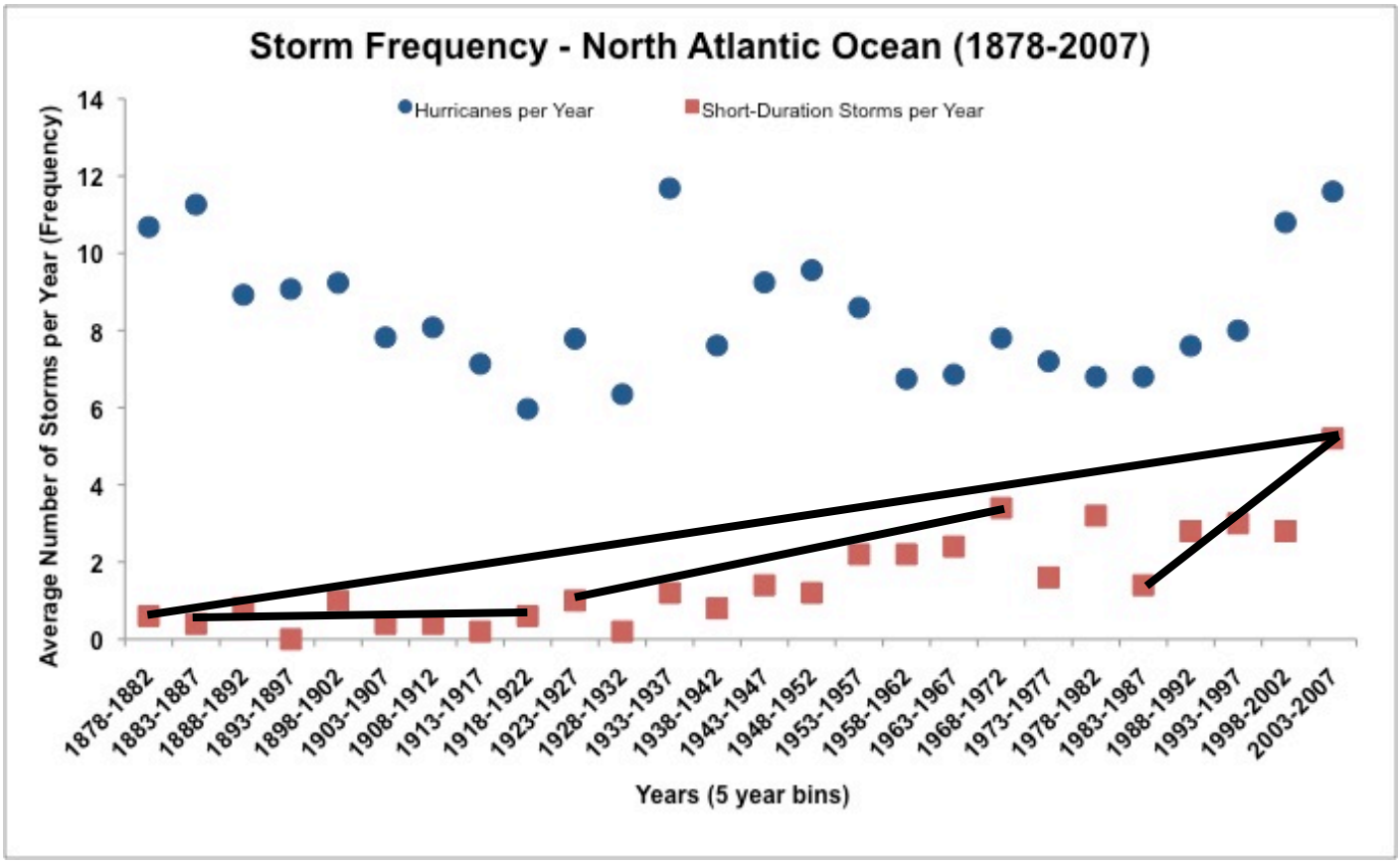
Hurricane Data Interpretation Questions:

1. What is the pattern in the number of hurricanes data from 1878 to 2007?
The pattern is variable throughout the dataset of highs and lows, but overall the average number of hurricanes is not changing with time. The average number of hurricanes is remaining consistent, from 10.7 in 1878-1882 to 11.6 in 2003-2007. The differences in the average number of hurricanes are not significant.

2. What is the pattern in the number of hurricanes data from 1983 to 2007?
The average number of hurricanes increased from 6.8 (1983-1987) to 11.6 (2003-2007) at a rate of about +0.2 hurricanes/year.

3. What is the pattern in the number of hurricanes data from 1883 to 1922?
The average number of hurricanes decreased from 11.3 (1883-1887) to 6.0 (1918-1922) at a rate of about -0.14 hurricanes/year.

4. What is the pattern in the number of hurricanes data from 1923 to 1972?
The average number of hurricanes did not change significantly from 7.8 (1923-1927) to 7.8 (1968-1972).



Short-Duration Storm Data Interpretation Questions:

1. What is the pattern in the number of short-duration storms data from 1878 to 2007?

The pattern is an increase in the average number of short-duration storms over time. The average number of short-duration storms increased from 0.6 in 1878-1882 to 5.2 in 2003-2007 at a rate of about +0.04 short-duration storms/year.

2. What is the pattern in the number of short-duration storms data from 1983 to 2007?

The average number of short-duration storms increased from 1.4 (1983-1987) to 5.2 (2003-2007) at a rate of about +0.16 short-duration storms/year.

3. What is the pattern in the number of short-duration storms data from 1883 to 1922?

The average number of short-duration storms did not change significantly from 0.4 (1883-1887) to 0.6 (1918-1922).

4. What is the pattern in the number of short-duration storms data from 1923 to 1972?

The average number of short-duration storms increased from 1 (1923-1927) to 3.4 (1968-1972) at a rate of about +0.05 short-duration storms/year.

Writing Prompt:

What patterns can you observe in the data? Is there a pattern between the number of hurricanes and time? If so, what is the pattern?

There is no overall pattern in the number of hurricanes over the past century.

Is there a pattern between the number of short-duration storms and time? If so, what is the pattern?

Overall there is an increase in the number of short-duration storms over the past century, especially since the 1950s.

Based upon your hypotheses and these data, do you think that climate change is influencing the number of hurricanes over time?

If climate change were influencing the number of hurricanes we would have expected to see an overall increasing pattern in the number of hurricanes over time in the past century (as the global temperature, sea surface temperature, and greenhouse gas concentrations in the atmosphere have increased). However, we do not see such a pattern in the data, therefore the data demonstrates that there is not an influence of climate change on the number of hurricanes over the past century.

Do you think climate change is influencing the number of short-duration storms over time?

Although we did observe an increase in the number of short-duration storms over the past century there is no reason why climate change would only be influencing the number of short-duration storms. However, this increase is consistent with what you would expect from improvements in technology and observational practices for recording short-duration storms. Therefore, the increase in the number of short-duration storms is more an artifact of better sampling than an influence of climate change.

Advanced Data Table – 1878-2007 North Atlantic Storm Counts (corrected for "unobserved hurricanes")

Years	Number of Hurricanes per Year	Number of Short-Duration Storms per Year
1878-1882	10.7	0.6
1883-1887	11.3	0.4
1888-1892	8.9	0.8
1893-1897	9.1	0
1898-1902	9.2	1
1903-1907	7.8	0.4
1908-1912	8.1	0.4
1913-1917	7.1	0.2
1918-1922	6.0	0.6
1923-1927	7.8	1
1928-1932	6.3	0.2
1933-1937	11.7	1.2
1938-1942	7.6	0.8
1943-1947	9.2	1.4
1948-1952	9.6	1.2
1953-1957	8.6	2.2
1958-1962	6.7	2.2
1963-1967	6.9	2.4
1968-1972	7.8	3.4
1973-1977	7.2	1.6
1978-1982	6.8	3.2
1983-1987	6.8	1.4
1988-1992	7.6	2.8
1993-1997	8.0	3
1998-2002	10.8	2.8
2003-2007	11.6	5.2