New Jersey Temperature Over Time

Materials

For the leader:

Projector

Whiteboard to project data graph onto

For the activity:

Copy of annual mean surface temperature data table

Computer program to graph in or graphing paper

Copy of student worksheet

Overview

Scientists use a range of evidence to look at changes in weather and climate patterns over time. In this activity students will look at surface temperatures from land stations near where they live to look at the changes in temperatures over time. The activity places a strong emphasis on teaching students how to handle raw data. The students first need to review/process the data, then plot it, and then interpret the data 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 in which you look at a long-term dataset can influence what conclusions you draw from the data. Through gaining these data interpretation skills, students will also gain a better understanding of how scientists look at evidence when asking questions about changes in the Earth's climate over time and observe an increase in annual surface temperature over the past century in central New Jersey.

Motivating Questions: **How do scientists study changes in temperature over time? What does that information tell us about the climate?**

Take Home Message

Scientists use multiple collecting stations around the world to gather temperature data to look at changes in surface temperatures over time. Using these data, scientists look for trends and patterns as well as anomalies to determine what is happening with surface temperatures on Earth and make predictions of what will happen in the future.

Engage: Lead the students in a discussion about what they know about the relationship between temperature, weather, and climate.	10 minutes
Explore: Students investigate data of the surface temperature for central New Jersey over the past century.	25 minutes
Make Sense: Students share their observations, ask questions, and discuss what they can learn from the central New Jersey temperature graphs.	10 minutes
Total:	**45 minutes**

Audience

Middle and high school students (6^{th}-12^{th} grade).

New Jersey Core Curriculum Content Standards - Science

Grade	Content Statement	CPI#
6	Weather is the result of short-term variations in temperature, humidity, and air pressure.	5.4.6.F.1
6	Climate is the result of long-term patterns of temperature and precipitation.	5.4.6.F.2
8	Mathematics and technology are used to gather, analyze, and communicate results.	5.1.8.B.2
8	Carefully collected evidence is used to construct and defend arguments.	5.1.8.B.3

8	Scientific reasoning is used to support scientific conclusions.	5.1.8.B.4
8 / 12	Science involves practicing productive social interactions with peers, such as partner talk, whole-group discussions, and small-group work.	5.1.8.D.1 / 5.1.12.D.1
12	Climate is determined by energy transfer from the Sun at and near Earth's surface.	5.4.12.F.2
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 defend arguments.	5.1.12.B.3
12	Scientific reasoning is used to evaluate and interpret data patterns and scientific conclusions.	5.1.12.B.4

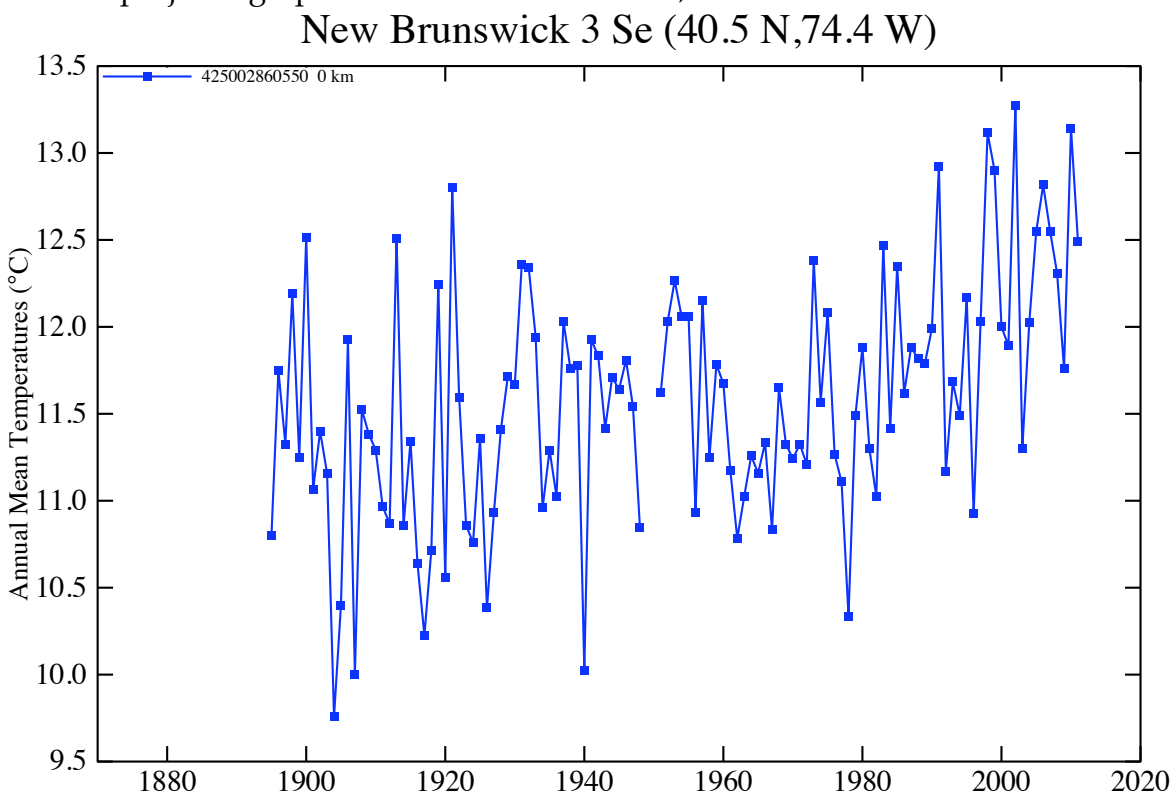
Preparation (20 minutes)

1. Write the motivating questions on the board:

   How do scientists study changes in temperature over time? What does that information tell us about the climate?

2. Make class copies of student worksheets for each student (at the end of this write-up).
3. Determine which data station you are going to use for the activity (the activity is written for the New Brunswick 3 Se station). If you are using the New Brunswick 3 Se station data, you can use the NewBrunswickSurfaceTemperatureData.xls file. If not, then visit NASA Goddard Institute for Space Studies GISS Surface Temperature Analysis website at: http://data.giss.nasa.gov/gistemp/station_data/.
   a. Under the "Download Station Data" section for "1) Select a specific data set from the pull-down menu below," choose "after GISS homogeneity adjustment."
   b. For the "2) Click at desired location on the map below **or** enter here a station name to search for:" either click in the map where you would like to pull a dataset from OR type in the station name (e.g., New Brunswick 3 Se) into the box.
   c. Click on the desired station name to access the data plot and downloadable data.
   d. Under the "Downloads" section, click on the "plot in Postscript form" to download a copy of the data plot to your computer. This will download as a .ps file that you can open in Preview or other image viewing software programs.
   e. Under the "Downloads" section, click on the "monthly data as text" to download the raw data. This will open as an html page.
      i. Place your cursor on the page and go to Edit → Select All and then Edit → Copy; you can then Edit → Paste the data into a new Excel spreadsheet.
      ii. The data will paste all in the same column, so to separate it out across multiple columns go to Data → Text to Columns. This will open a "Convert Text to Columns Wizard" window, select Delimited and Next. On the next page in the Delimiters section, select Space (you should be able to see the columns separated accurately in the Data Preview section at the bottom of the window) and Next. On the next page select Finish.
      iii. Save the excel file as you would like. When looking at the data the columns represent the year of record, months (January through December), seasons (Winter: D-J-F; Spring: M-A-M; Summer: J-J-A; and Fall: S-O-N), and the annual mean (metANN) for the dataset. Make any desired adjustments to the data table to make it easier for your students to complete the activity.

4. Make or project a graph of the data on the board, but make sure it is hidden from the students.



Engage (10 minutes)

1. Lead the students in a discussion about the relationship between temperature, weather, and climate.

Q. What is the relationship between temperature and weather? What questions are scientists trying to answer when they collect information from surface temperatures?

Q. What is the difference between weather and climate?

Q. How do scientists study weather and climate?

Q. Why do scientists study the climate?

Q. Why would scientists be interested in understanding changes in surface temperatures over time in different regions and throughout the world?

2. Ask the students what they know about techniques used to collect data about surface temperatures. Be accepting of all responses from the students.
3. After a minute or two, 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.

Explore (25 minutes)

1. Explain to the students that they will be taking a closer look at surface temperatures in central New Jersey over the past century. In fact they will be making their own plots of surface temperatures to look for patterns, trends, and anomalies 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 annual mean surface temperatures[1] from the New Brunswick, NJ temperature station from 1895 to 2012.
    b. First, they need to look at the data to check for outliers, 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 far different than the others. (Note – when there is not a data point for a month from the temperature station that is listed in the data table as 999.9, these are the outliers the students should be finding.)
    c. If, or once, they find data points that are not actual data points (it was not 999.9°C in 1949, 1950, and 2012), the students should decide what they want to do about those data points. Do they throw them out? Do they make them zero? Do they plot them as 999.9°C? Let them discuss this in their groups.
3. Ask the students if they have any questions about the data processing portion of the activity. What did they decide about the outliers? Call on different students or student groups to share their opinions of what they should do about the outlier data. Allow them to discuss 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.
4. 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 plot the annual mean surface temperature data for the New Brunswick, NJ temperature station.
    b. Ask the students:
        i. What kind of graph will we use? (Marked Line graph)
        ii. What is the x-axis? (Years)
        iii. What is on the y-axis? (Annual Mean Surface Temperature in °C)
        iv. Do we connect the data points from each year? (Yes, because surface temperature is a continuous variable, meaning there is a temperature at every moment in time at that location between the two data points.)
        v. Does the line connecting the data points represent the patterns or trends in the data? (No)
    c. Have the students look at the data to find trends, patterns, and anomalies in the annual mean surface temperature data for New Brunswick, NJ by completing the student worksheet.
5. 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 annual mean surface temperature and time? If so, what is the pattern?

[1] Possible extensions or variations of this activity include having the students plot the seasonal data, plot the monthly data, and plot data from multiple stations around the US or world.

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, trends, and/or anomalies they observed in the data over different time scales in the dataset. Make sure to have the students support their statements of the patterns, trends, and/or anomalies by stating what evidence they are using.
    a. Help the students see that the pattern in annual mean surface temperature is variable over time, but that overall the surface temperature has increased over the course of the dataset.
    b. Ask the students if they found any anomalies in the dataset, e.g., 1940 is much lower than the other years in the decade. This does not mean that it is a bad data point, but rather highlights the natural variability that exists on short time scales within temperature. This would represent a change in the weather from one winter to the next, but does not indicate a change in the climate.
    c. Help the students see that from 1895 to 2011 the overall trend is an increase in annual mean surface temperature from 10.8°C to 12.49°C. However, the observed trend in annual mean surface temperature varies depending on what time scale you look at in the dataset: e.g., decreases from 1900 to 1948, increases from 1948 to 2011, stays the same from 1939 to 1960 and 1980 to 2001, dramatically increases from 1904 to 1921 and 1978 to 2002.
3. Lead the students in a discussion about these differences in observed trends of the annual mean surface temperature data. Some discussion points you might want to hit on:
    a. Help the students think about how if we are only looking at year-to-year variation (weather) in annual mean surface temperature data we will miss the larger trends over time (climate).
    b. Help the students think about how the time frame that you use to talk about trends in the annual mean surface temperature has a large influence on your conclusions of what the trend in the data is.
        i. What does that mean for making conclusions about data?
        ii. What time frame should we look at if we are interested in weather patterns?
        iii. What time frame should we look at if we are interested in climate patterns?
4. Once the discussion slows down, point to the motivating questions and ask:
   Q. How do scientists study changes in temperature over time? What does that information tell us about the climate?
5. Ask students to share their ideas about the questions with a partner. 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" that you identified.
6. Ask if the students have any final questions about the activity, data processing/graphing, or relationship between temperature and climate.

New Jersey Temperature Over Time Worksheet

Name: _____

Date: _____

Station Name _____

Data Interpretation Questions:

1. Describe the overall pattern of annual mean surface temperature data.

2. Are there any anomalies in the annual mean surface temperature data?

3. What is the overall trend in the annual mean surface temperature data?

4. What is the trend in the annual mean surface temperature data from 1900 to 1948? From 1948 to 2011?

5. What is the trend in the annual mean surface temperature data from 1939 to 1959? From 1980 to 2001? From 1904 to 1921? From 1978 to 2002?

Writing Prompt:

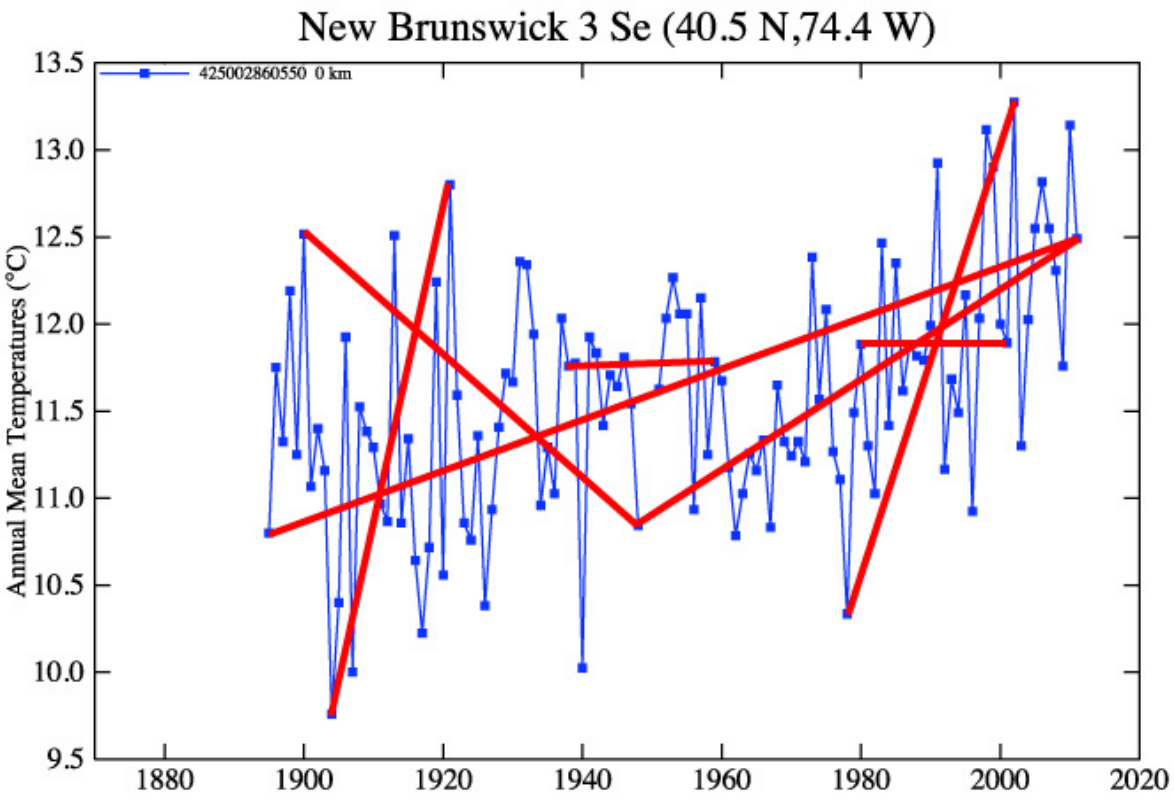
What patterns can you observe in the data? Is there a pattern between annual mean surface temperature and time? If so, what is the pattern?

New Jersey Temperature Over Time Worksheet – Answer Key for New Brunswick, NJ station

Name: _____

Date: _____

Station Name __New Brunswick 3 Se (40.5 N, 74.4 W) [New Jersey]_____



Data Interpretation Questions:

1. Describe the overall pattern of annual mean surface temperature data.
The pattern is variable throughout the dataset of highs and lows, but overall the annual mean surface temperature is increasing.

2. Are there any anomalies in the annual mean surface temperature data?
Yes, in 1940 the annual mean surface temperature was extremely lower than other temperatures of the decade. This does not mean it is bad data, but just points to the variability from year-to-year.

3. What is the overall trend in the annual mean surface temperature data?
The annual mean surface temperature is increasing from 10.8°C (1895) to 12.49°C (2011) at a rate of +0.015°C/year.

4. What is the trend in the annual mean surface temperature data from 1900 to 1948? From 1948 to 2011?

The annual mean surface temperature is decreasing from 12.52°C (1900) to 10.3°C (1948) at a rate of -0.046°C/year but increasing from 10.3°C (1948) to 12.49°C (2011) at a rate of +0.035°C/year.

5. What is the trend in the annual mean surface temperature data from 1939 to 1959? From 1980 to 2001? From 1904 to 1921? From 1978 to 2002?

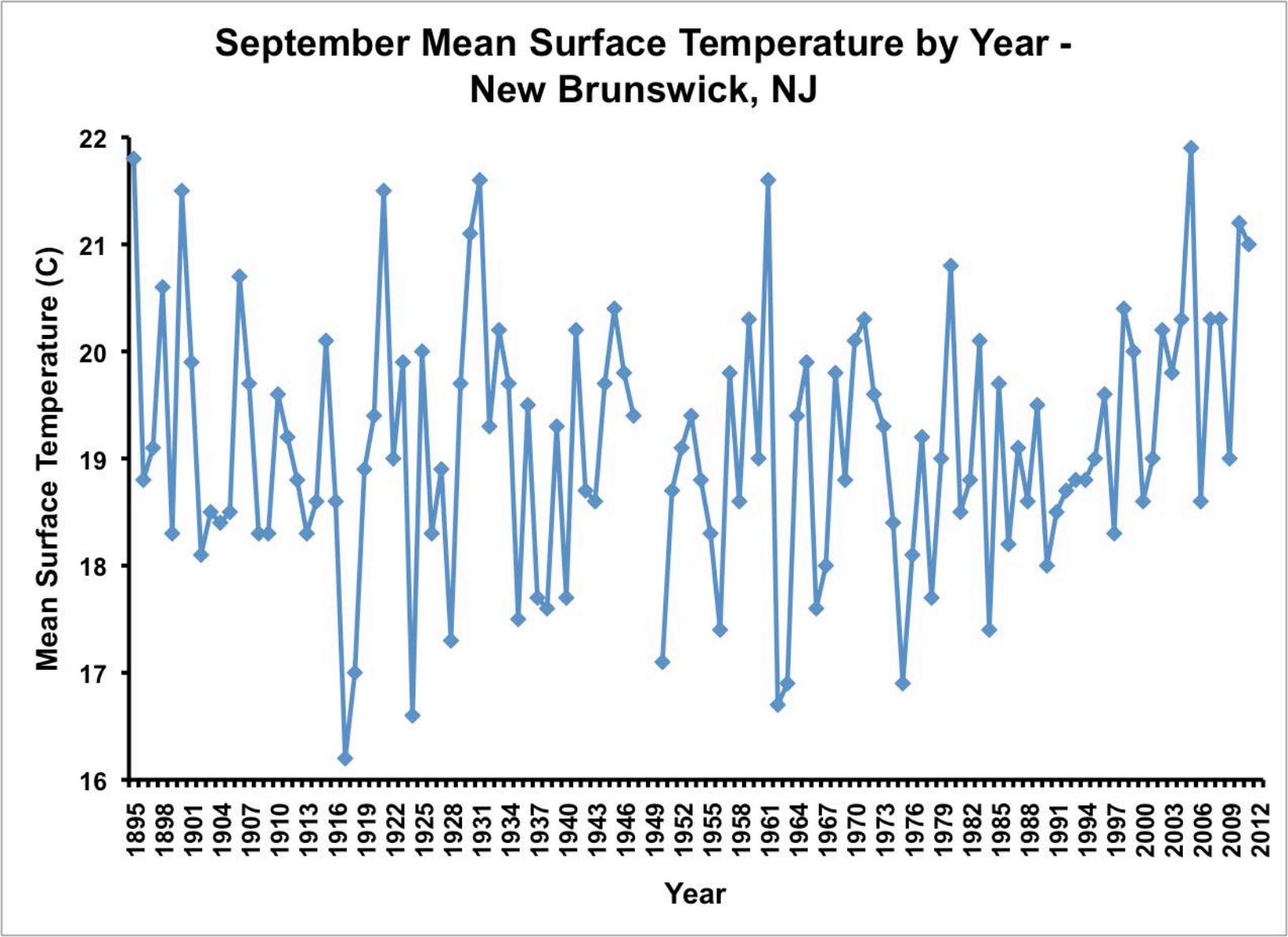
The annual mean surface temperature is steady from 11.78°C (1939) to 11.78°C (1959) and from 11.88°C (1980) to 11.89°C (2001). But the annual mean surface temperature rapidly increased from 9.76°C (1904) to 12.8°C (1921) at a rate of +0.203°C/year and from 10.34°C (1978) to 13.28°C (2002) at a rate of +0.123°C/year.

Writing Prompt:

What patterns can you observe in the data? Is there a pattern between annual mean surface temperature and time? If so, what is the pattern?

Data Table – New Brunswick 3 Se (1895 to 2011) Annual Mean Surface Temperature

Year	Annual	1924	10.76	1954	12.06	1984	11.42
1895	10.8	1925	11.36	1955	12.06	1985	12.35
1896	11.75	1926	10.38	1956	10.93	1986	11.62
1897	11.32	1927	10.93	1957	12.15	1987	11.88
1898	12.19	1928	11.41	1958	11.25	1988	11.82
1899	11.25	1929	11.72	1959	11.78	1989	11.79
1900	12.52	1930	11.67	1960	11.68	1990	11.99
1901	11.07	1931	12.36	1961	11.18	1991	12.93
1902	11.4	1932	12.34	1962	10.78	1992	11.17
1903	11.16	1933	11.94	1963	11.03	1993	11.68
1904	9.76	1934	10.96	1964	11.26	1994	11.49
1905	10.4	1935	11.29	1965	11.16	1995	12.17
1906	11.93	1936	11.03	1966	11.33	1996	10.93
1907	10	1937	12.03	1967	10.83	1997	12.03
1908	11.53	1938	11.76	1968	11.65	1998	13.12
1909	11.38	1939	11.78	1969	11.32	1999	12.9
1910	11.29	1940	10.03	1970	11.24	2000	12
1911	10.97	1941	11.93	1971	11.32	2001	11.89
1912	10.87	1942	11.83	1972	11.21	2002	13.28
1913	12.51	1943	11.42	1973	12.38	2003	11.3
1914	10.86	1944	11.71	1974	11.57	2004	12.03
1915	11.34	1945	11.64	1975	12.08	2005	12.55
1916	10.64	1946	11.81	1976	11.27	2006	12.82
1917	10.22	1947	11.54	1977	11.11	2007	12.55
1918	10.72	1948	10.84	1978	10.34	2008	12.31
1919	12.24	1949	999.9	1979	11.49	2009	11.76
1920	10.56	1950	999.9	1980	11.88	2010	13.14
1921	12.8	1951	11.62	1981	11.3	2011	12.49
1922	11.59	1952	12.03	1982	11.03	2012	999.9
1923	10.86	1953	12.27	1983	12.47		


September Mean Surface Temperature by Year -
New Brunswick, NJ
Mean Surface Temperature (C)
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