A change in the weather.

I. UNIT OVERVIEW & PURPOSE:
This unit will allow students to research climate change and explore ideas regarding trends, causes, implications and recommended courses of actions through data collection, analysis and modeling.

II. UNIT AUTHOR:
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III. COURSE:
Mathematical Modeling: Capstone Course

IV. CONTENT STRAND:
Data Analysis and Probability

V. OBJECTIVES:
Survey design
Data collection
Univariate data analysis
Bivariate data analysis
Linear and/or nonlinear modeling

VI. MATHEMATICS PERFORMANCE EXPECTATION(s):
MPE.2 Collect and analyze data, determine the equation of the curve of best fit, make predictions, and solve real-world problems using mathematical models. Mathematical models will include polynomial, exponential, and logarithmic functions.

MPE.8 Compare distributions of two or more univariate data sets, analyzing center and spread (within group and between group variations), clusters and gaps, shapes, outliers, or other unusual features.

MPE.9 Design and conduct an experiment/survey. Key concepts include
a) sample size;
b) sampling technique;
c) controlling sources of bias and experimental error;
d) data collection; and
e) data analysis and reporting.

MPE.12 Transfer between and analyze multiple representations of functions, including algebraic formulas, graphs, tables, and words. Select and use appropriate representations for analysis, interpretation, and prediction.

MPE.14 Recognize the general shape of function (absolute value, square root, cube root, rational, polynomial, exponential, and logarithmic) families and convert between graphic and symbolic forms of functions. Use a transformational approach to graphing. Use graphing calculators as a tool to investigate the shapes and behaviors of these functions.

MPE.16 Investigate and analyze functions (linear, quadratic, exponential, and logarithmic families) algebraically and graphically. Key concepts include
a) continuity;
b) local and absolute maxima and minima;
c) domain and range, including limited and
discontinuous domains and ranges;
d) zeros;
e) x- and y-intercepts;
f) intervals in which a function is increasing or decreasing;
g) asymptotes;
h) end behavior;
i) inverse of a function;
j) composition of multiple functions;
k) finding the values of a function for elements in its domain; and
l) making connections between and among multiple representations of functions including concrete, verbal, numeric, graphic, and algebraic.

MPE.19 Graph linear equations and linear inequalities in two variables, including
a) determining the slope of a line when given an equation of the line, the graph of the line, or two points on the line; describing slope as rate of change and determine if it is positive, negative, zero, or undefined; and
b) writing the equation of a line when given the graph of the line, two points on the line

MPE.22 Analyze graphical displays of univariate data, including dotplots, stemplots, and histograms, to identify and describe patterns and departures from patterns, using central tendency, spread, clusters, gaps, and outliers. Use appropriate technology to create graphical displays.

VII. CONTENT:
In addition to the mathematics covered, students will have the opportunity to learn about meteorology, ecology, earth science and communications.

VIII. REFERENCE/RESOURCE MATERIALS:

http://www.pbs.org/teachers/stem/professionaldevelopment/020/engage/

http://www.climatechoices.org.uk/pages/activities0.htm#p1

http://unfccc.int/resource/iuckit/cckit2001en.pdf

http://climate.nasa.gov/interactives/climate_time_machine

http://www.climatewizard.org/

http://www.epa.gov/climatestudents/

http://www.almanac.com/weather/history

http://osep.northwestern.edu/sites/default/files/Arctic%20Ice%20Data_ALL.pdf

http://serc.carleton.edu/eslabs/drought/3.html

IX. PRIMARY ASSESSMENT STRATEGIES:
Peer/Self Assessment and teacher assessment of final products.

X. EVALUATION CRITERIA:
Rubrics attached.

XI. INSTRUCTIONAL TIME:
Five to eight 90-minute blocks.

A change in the weather.

Student Exploration 1:

Students will consider the power and meaning of mathematics. This lesson will introduce students to Likert-type surveys, and provide an opportunity for students to begin thinking about the power of mathematics to reveal information about their world.

Mathematical Objective(s):
Students will be introduced to a Likert-type scale and informal interviews to gather qualitative data. The data will be displayed graphically and presented to the class.

Additional Objectives for Student Learning:
Students will reflect on the power of mathematics as a tool for understanding and as an agent for change. Students will begin to explore the nature of climate and climate change.

Materials/Resources:

- Student survey handout or online access to a free data collection website such as Survey Monkey
- Graphing calculator or spreadsheet software
- Presentation materials such as poster board or presentation software

Assumption of Prior Knowledge

- Students should be familiar with basic data collection techniques
- Students should be familiar with measures of central tendency and measures of spread
- Students should know about the 5-number summary, quartiles and box-and-whisker plots
- Students should be familiar with a variety of techniques (pie charts, bar graphs) to display statistical data

Student/Teacher Actions:

- Students will respond to five questions regarding their beliefs about the power of mathematics. This data will be collected using a Likert-type scale. Teacher may gather this data on the attached handout #1 or through an online survey for students, if convenient.
- The teacher will have the students compile the data. This may be done by having them transfer responses on the board, enter them into a spread sheet or any other teacher-selected method that suits the class.

- After the data is compiled, the teacher should engage students in discussion about the meaning and value of qualitative data, as well as student opinions about the power of mathematics.
- The teacher will ask students to describe any possible significance in the data. Will analysis of the data reveal characteristics of the class? Can this data be used by students to guide their participation in class? Can it be used by the teacher to inform instruction?
- The teacher will lead a discussion about analysis of the data. What statistical measures of the data might be revealing? Are measures of center or measures of spread appropriate to describe the results?
- The teacher will lead the class in discussion about presentation of results. What sorts of visual representations might be helpful to explain the data? Box and whisker plots? Pie charts? Bar graphs? Ask students to explain their suggestions.
- Divide the class into groups, and assign each group one question to analyze and present. Use Excel Spreadsheets or the graphing calculator to analyze the data. The teacher may use handout #2 to guide the groups in the task.
- The following block, each group will present their analysis to the class. Students will complete peer/self rubrics for their own group, and other groups in the class.

Name____ Date_______ HO#1

Please respond to the following questions by rating how strongly you agree with the following statements. 4 means strong agreement, 0 means strong disagreement. 2 means no opinion or belief.

	0 strongly disagree	1 disagree	2 no opinion	3 agree	4 strongly agree
I believe that mathematics can help people understand the world around them.					
I believe that professional mathematicians can use mathematics to help me understand the world.					
I believe that I can do mathematics for myself that will help me understand the world.					
I believe that I can do mathematics that will help others around me to understand the world.					
I believe that I can use mathematics to help make positive changes in the world.					

Name____ Date______HO#2
Analyzing your question

Summarize the responses to your assigned question below.

Your Question	0 strongly disagree	1 disagree	2 no opinion	3 agree	4 strongly agree

1. Find the measures of central tendency for your data.

2. Calculate the 5-number summary.

3. How does this information give you insight into your data? Explain your thoughts.

4. What else about the data might reveal information about your class? Explore the data as deeply as you can and explain your ideas.

5. Create a visual display of the data based on your teacher's directions.

6. Write a brief explanation of the significance of the responses to the question.

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Name____ Date______HO#3
Peer/Self Rubric

In each category, rate each group from 0, meaning they did not complete that aspect of the assignment, to 4, meaning they exceeded your expectations. A score of 2 means that the group meets your basic expectations for an aspect of the activity.

Group Question	The group used statistics to explore the data.	The group analyzed the statistics and formed a valid conclusion about the class attitudes.	The group created an appropriate chart or graph to display their results.	The group clearly presented their analysis to the class, and clearly communicated their conclusions.
I believe that mathematics can help people understand the world around them.				
I believe that professional mathematicians can use mathematics to help me understand the world.				
I believe that I can do mathematics for myself that will help me understand the world.				
I believe that I can do mathematics that will help others around me to understand the world.				
I believe that I can use mathematics to help make positive change in the world.				

Arrive at a letter grade for your group. Explain your reasons.

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Student Exploration 2:

Students will begin exploring the topic of climate change by gathering opinions of family and friends.

Mathematical Objective(s):
Students will create a Likert-type questionnaire and gather qualitative data. The data will be displayed graphically and presented to the class.

Additional Objectives for Student Learning:
Students will begin to explore the nature of climate and climate change.

Materials/Resources:

- Computers with internet access
- Access to spread sheet software or graphing calculators
- Presentation materials
- Attached handouts

Assumption of Prior Knowledge:

- Univariate data analysis
- Measures of center
- Measures of spread
- Knowledge of data collection

Student/Teacher Actions:

- The teacher will engage students in a discussion about the topic of climate change. One possibility is to show a short video on one interesting aspect of climate change suited to the class personality. Some options are listed:

  Climate change and penguins
  http://www.youtube.com/watch?v=E9sDnqZyg20

  Glacier calving
  http://www.youtube.com/watch?v=n1L8tLLdBMs

  Venice flooding
  http://www.youtube.com/watch?v=3ltDKRfbaKM

  North Carolina Beach Erosion
  http://www.youtube.com/watch?v=YsKC0fQHU-M

- The teacher will have the class discuss their knowledge and opinions on the topic. They will jointly develop a Likert-type questionnaire to gather data on community opinions and knowledge regarding climate change. Students may create a list of questions that they have about attitudes, information and personal experiences with climate change. Students may create hand outs or use online survey service to write their questionnaire and collect data.
- Before the end of class, students will have a single Likert-type questionnaire with no fewer than 5 questions about opinions and observations about climate change. Additionally, the class will agree upon a set of no fewer than 3 three interview questions to gather anecdotal evidence of climate change over the lives of family members or friends.
- Each student will be directed to collect data from no fewer than three friends or family members of different ages. The age of each respondent must be recorded for use in the data analysis. This data must come back to class for the following block.
- Teachers may use hand out #4 for student use if necessary. Each student would need 3 copies.
- Students may bring in photos showing extreme weather or snow conditions in past years, newspaper clippings about weather related events or other supporting evidence.
- During the following class period the students will compile the data for the entire class.
- In small collaborative groups, the students will begin sharing the anecdotal evidence of climate change. As a class, create a time line of remembrances of climate conditions from the date of birth of the oldest respondent to the present. Local historical data may be added to the time line as it is gathered.
- In collaborative groups, students will analyze the Likert-type responses as they did in the first exploration. Similarly, students will prepare an analysis of the responses, and a presentation of their conclusions. The teacher should monitor student work to ensure that they are developing conclusions about attitudes and developing questions about the facts surrounding climate change.

Name____ Date_______ HO#4

Climate Change Opinions Questionnaire

Record the questions that the class agrees upon below. Be sure to explain the meaning of each numerical response.

	0	1	2	3	4

List the interview questions that you will ask your family and friends. They should relate to their perceptions of climate change over their lives. For each person you ask, please record all of their responses as well as their year of birth.

Question #1: year of birth

Question #2:

Question #3:

Additional Questions:

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Name____ Date______HO#5
Peer/Self Rubric Climate Change Questionnaire

In each category, rate each group from 0, meaning they did not complete that aspect of the assignment, to 4, meaning they exceeded your expectations. A score of 2 means that the group meets your basic expectations for an aspect of the activity.

Group Question	The group used statistics to explore the data.	The group analyzed the statistics and formed a valid conclusion.	The group created an appropriate chart or graph to display their results.	The group clearly presented their analysis to the class, and clearly communicated their conclusions.

Arrive at a letter grade for your group. Explain your reasons.

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Student Exploration 3:

Students will be introduced to or review scatter plots and correlation.

Mathematical Objective(s):

- The student will plot data in a scatter plot.
- The student will create a model to represent the data.
- The student will interpret data.
- The student will use the model to extrapolate.

Additional Objectives for Student Learning:

Students will begin to explore the nature of climate and climate change.

Materials/Resources:

- Computers with internet access
- Access to spread sheet software or graphing calculators
- Presentation materials
- Attached handouts

Assumption of Prior Knowledge:

- Students should be familiar with basic data collection techniques
- Students should be familiar with measures of central tendency and measures of spread
- Students should know about the 5-number summary, quartiles and box-and-whisker plots
- Students should be familiar with a variety of techniques(pie charts, bar graphs) to display statistical data

Student/Teacher Actions:

- The teacher will provide students with historical data regarding recorded air temperature at the Richmond airport for the month of February. This data set shows relatively stable temperature over the time period. Allow class discussion about possible reasons for this seeming contradiction.
- Students will explore the data set by creating a scatter plot and discussing possible correlations. This may be done in Excel, on a graphing calculator or by hand based on the needs and resources of the class.
    - The teacher may provide this data in several ways, depending on the resources and personality of the class:
        - Have students research the data at http://www.sercc.com/climateinfo/historical/historical_va.html

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- Provide students at computers stations with an Excel spread sheet or cut-and-paste electronic list of data
- Provide handout #6 for students using graphing calculators or graph paper
    - Differentiation: Use handout #6A for a friendlier and abbreviated version of the same data set. Certain students may find a friendlier data set more inviting for an introductory exploration. Use handout #6B to compare day time high temperatures with mean daily temperatures for students who are prepared to compare related data sets.
    - Extensions: Have students analyze each set of univariate data to look for an overall mean and potential outliers.

- After looking at the data for January, analyze the month of August in a similar fashion. Data is given in handout #7, #7A and #7B. August data will show a gradual increase in temperature over time.
- The teacher will have students add actual temperature data from these data sets to their time line.
- Whole class discussion will allow students to reflect on the meaning of the data as well as the methods of analysis.

*Notes to the teacher: The data for the month of January will show relatively little change in temperature, with a stronger positive trend for the month of August. Scale of graphs will emphasize or deemphasize the trends. The data appears somewhat cyclical – if your class notices this, you may explore solar cycles or look for more complex mathematical models to explain the apparent cycles. You may choose to have your class perform univariate data analysis on the mean temperatures to look for outliers or extremes that they do not want to consider in the trend analysis.

Below, Excel scatter plots show very different results for data including 1949 and 1950, and data starting in 1951. You may choose to do each with your class, and discuss possible reasons, or choose to limit your domain. Also note that climate change in Virginia has been more moderate than in other parts of the world – which we will explore later.

Chart 1: January 1948 to 2013

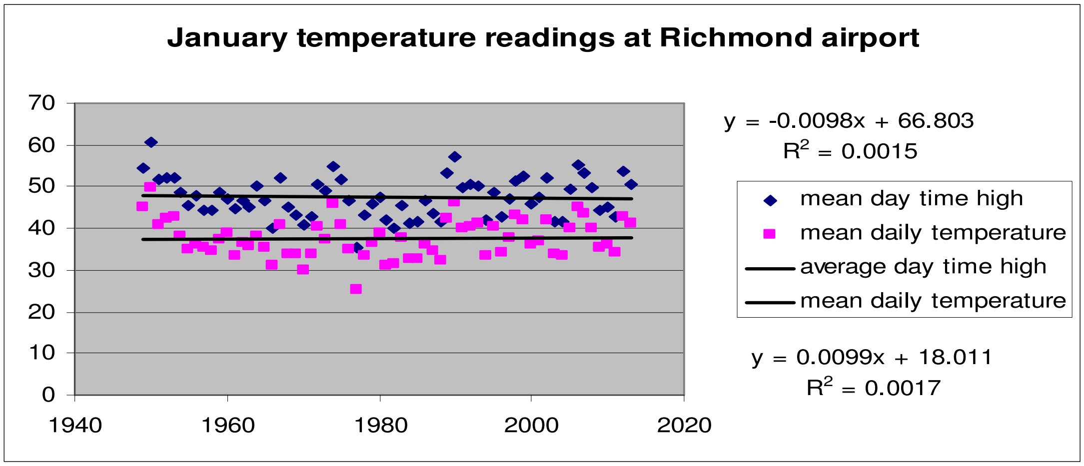


Chart 2: January 1951 to 2013

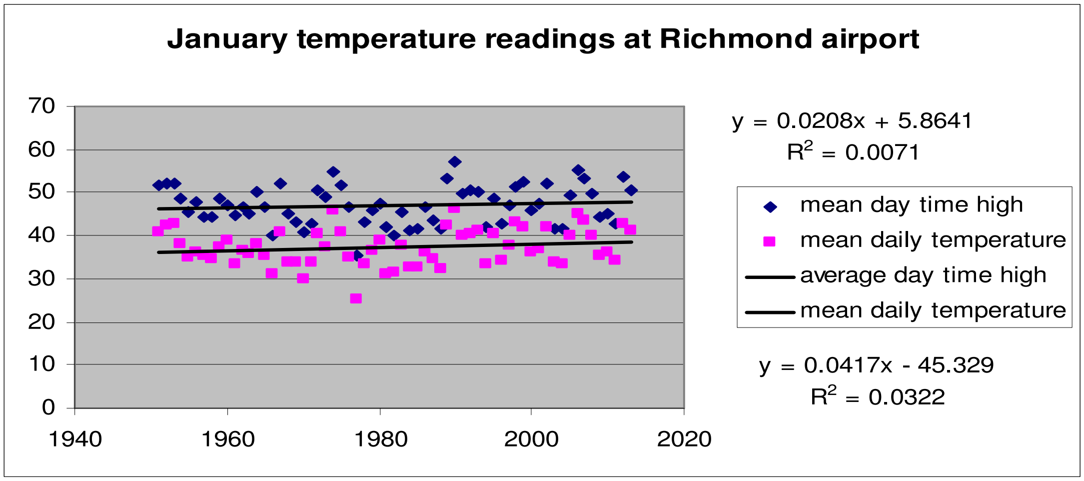
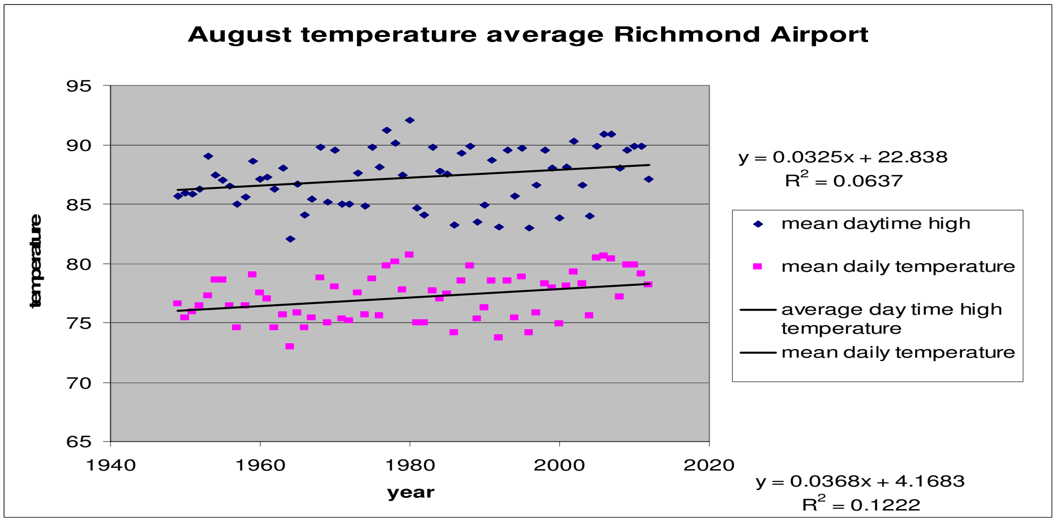


Chart 3: August 1949 to 2012



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Name____ Date_______ HO#6

The National Weather Service began recording the temperature at the airport in Richmond, Virginia in 1948. They maintain data on the warmest time of the day, the coolest time of the day and the average daily air temperature.

The following data set shows the average daily temperature for the month of January.

Year	**Temp**
1949	45.3
1950	49.7
1951	40.9
1952	42.4
1953	42.8
1954	38
1955	35.1
1956	36
1957	35.2
1958	34.5
1959	37.5
1960	38.7
1961	33.4
1962	36.5
1963	35.8
1964	38

Year	**Temp**
1965	35.5
1966	31.1
1967	40.9
1968	33.9
1969	33.9
1970	30
1971	33.8
1972	40.6
1973	37.5
1974	45.8
1975	40.7
1976	35.1
1977	25.2
1978	33.3
1979	36.4
1980	38.7

Year	**Temp**
1981	31.1
1982	31.6
1983	37.8
1984	32.6
1985	32.6
1986	36.2
1987	34.7
1988	32.3
1989	42.3
1990	46.3
1991	40.2
1992	40.6
1993	41.4
1994	33.4
1995	40.6
1996	34.1

Year	**Temp**
1997	37.6
1998	43.2
1999	41.9
2000	36.3
2001	37.1
2002	42.1
2003	33.7
2004	33.3
2005	40
2006	45
2007	43.5
2008	40
2009	35.2
2010	36
2011	34.4
2012	42.6

Source: Southeast Regional Climate Center http://www.sercc.com/

Name____ Date_______ HO#6A

The National Weather Service began recording the temperature at the airport in Richmond, Virginia in 1948. They maintain data on the warmest time of the day, the coolest time of the day and the average daily air temperature.

The following data set shows the average daily temperature for the month of January.

Year	**Temp**
1950	50
1952	42
1954	38
1956	36
1958	35
1960	39
1962	37
1964	38

Year	**Temp**
1966	31
1968	34
1970	30
1972	41
1974	46
1976	35
1978	33
1980	39

Year	**Temp**
1982	32
1984	33
1986	36
1988	32
1990	46
1992	41
1994	33
1996	34

Year	**Temp**
1998	43
2000	36
2002	42
2004	33
2006	45
2008	40
2010	36
2012	42

Source: Southeast Regional Climate Center http://www.sercc.com/

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Name____ Date_______ HO#6B

The National Weather Service began recording the temperature at the airport in Richmond, Virginia in 1948. They maintain data on the warmest time of the day, the coolest time of the day and the average daily air temperature. The following data set shows the average daily high temperature and the mean daily temperature for the month of January.

Year	High	Mean
1949	54.6	45.3
1950	60.5	49.7
1951	51.6	40.9
1952	52.1	42.4
1953	52.2	42.8
1954	48.8	38
1955	45.5	35.1
1956	47.7	36
1957	44.5	35.2
1958	44.5	34.5
1959	48.6	37.5
1960	47	38.7
1961	44.8	33.4
1962	46.5	36.5
1963	45.3	35.8
1964	50.3	38
1965	46.5	35.5
1966	40.2	31.1
1967	52.2	40.9
1968	45.1	33.9
1969	43	33.9
1970	40.8	30
1971	42.7	33.8
1972	50.4	40.6
1973	49.1	37.5
1974	55	45.8
1975	51.7	40.7
1976	46.7	35.1
1977	35.2	25.2
1978	43	33.3
1979	45.9	36.4
1980	47.3	38.7

Year	High	Mean
1981	42.1	31.1
1982	40.2	31.6
1983	45.4	37.8
1984	41.1	32.6
1985	41.8	32.6
1986	46.5	36.2
1987	43.6	34.7
1988	41.7	32.3
1989	53.4	42.3
1990	57.2	46.3
1991	49.7	40.2
1992	50.7	40.6
1993	50.3	41.4
1994	41.9	33.4
1995	48.8	40.6
1996	42.7	34.1
1997	47.22	37.6
1998	51.5	43.2
1999	52.4	41.9
2000	46	36.3
2001	47.5	37.1
2002	52.3	42.1
2003	41.5	33.7
2004	41.8	33.3
2005	49.3	40
2006	55.4	45
2007	53.1	43.5
2008	49.8	40
2009	44.5	35.2
2010	45.1	36
2011	42.8	34.4
2012	53.5	42.6

Source: Southeast Regional Climate Center http://www.sercc.com/

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Name____ Date_______ HO#7

The National Weather Service began recording the temperature at the airport in Richmond, Virginia in 1948. They maintain data on the warmest time of the day, the coolest time of the day and the average daily air temperature.

The following data set shows the average daily temperature for the month of August.

Year	Mean
1949	76.6
1950	75.4
1951	75.9
1952	76.4
1953	77.3
1954	78.6
1955	78.6
1956	76.4
1957	74.6
1958	76.4
1959	79
1960	77.5
1961	77
1962	74.6
1963	75.7
1964	73

Year	Mean
1965	75.8
1966	74.6
1967	75.4
1968	78.8
1969	75
1970	78
1971	75.3
1972	75.2
1973	77.5
1974	75.7
1975	78.7
1976	75.6
1977	79.8
1978	80.1
1979	77.8
1980	80.7

Year	Mean
1981	75
1982	75
1983	77.7
1984	77
1985	77.4
1986	74.2
1987	78.5
1988	79.8
1989	75.3
1990	76.3
1991	78.5
1992	73.7
1993	78.5
1994	75.4
1995	78.9
1996	74.2

Year	Mean
1997	75.8
1998	78.3
1999	77.9
2000	74.9
2001	78.1
2002	79.3
2003	78.3
2004	75.6
2005	80.5
2006	80.6
2007	80.4
2008	77.2
2009	79.9
2010	79.9
2011	79.1
2012	78.2

Source: Southeast Regional Climate Center http://www.sercc.com/

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Name____ Date_______ HO#7A

The National Weather Service began recording the temperature at the airport in Richmond, Virginia in 1948. They maintain data on the warmest time of the day, the coolest time of the day and the average daily air temperature.

The following data set shows the average daily temperature for the month of August.

year	mean
1950	75.4
1952	76.4
1954	78.6
1956	76.4
1958	76.4
1960	77.5
1962	74.6
1964	73
1966	74.6
1968	78.8
1970	78
1972	75.2
1974	75.7
1976	75.6
1978	80.1
1980	80.7

Year cont.	Mean cont.
1982	75
1984	77
1986	74.2
1988	79.8
1990	76.3
1992	73.7
1994	75.4
1996	74.2
1998	78.3
2000	74.9
2002	79.3
2004	75.6
2006	80.6
2008	77.2
2010	79.9
2012	78.2

Source: Southeast Regional Climate Center http://www.sercc.com/

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Name____ Date_______ HO#7B

The National Weather Service began recording the temperature at the airport in Richmond, Virginia in 1948. They maintain data on the warmest time of the day, the coolest time of the day and the average daily air temperature.

The following data set shows the average daily high temperature and the mean daily temperature for the month of August.

Year	High	Mean
1949	85.7	76.6
1950	85.9	75.4
1951	85.8	75.9
1952	86.3	76.4
1953	89	77.3
1954	87.4	78.6
1955	87	78.6
1956	86.5	76.4
1957	85	74.6
1958	85.6	76.4
1959	88.6	79
1960	87.1	77.5
1961	87.3	77
1962	86.3	74.6
1963	88	75.7
1964	82.1	73
1965	86.7	75.8
1966	84.1	74.6
1967	85.4	75.4
1968	89.8	78.8
1969	85.2	75
1970	89.5	78
1971	85	75.3
1972	85	75.2
1973	87.6	77.5
1974	84.8	75.7
1975	89.8	78.7
1976	88.1	75.6
1977	91.2	79.8
1978	90.1	80.1
1979	87.4	77.8
1980	92.1	80.7

Year	High	Mean
1981	84.7	75
1982	84.1	75
1983	89.8	77.7
1984	87.8	77
1985	87.5	77.4
1986	83.2	74.2
1987	89.3	78.5
1988	89.9	79.8
1989	83.5	75.3
1990	84.9	76.3
1991	88.7	78.5
1992	83.1	73.7
1993	89.5	78.5
1994	85.7	75.4
1995	89.7	78.9
1996	83	74.2
1997	86.6	75.8
1998	89.5	78.3
1999	88	77.9
2000	83.8	74.9
2001	88.1	78.1
2002	90.3	79.3
2003	86.6	78.3
2004	84	75.6
2005	89.9	80.5
2006	90.9	80.6
2007	90.9	80.4
2008	88	77.2
2009	89.5	79.9
2010	89.9	79.9
2011	89.9	79.1
2012	87.1	78.2

Source: Southeast Regional Climate Center http://www.sercc.com/

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Student Exploration 4:

Students will explore climate change data from around the globe. Climate change in Virginia has been relatively slight compared to other parts of the world. To get a better idea of the scope of climate change, groups of students will look at data from weather stations around the world.

Mathematical Objective(s):

- The student will plot data in a scatter plot.
- The student will create a model to represent the data.
- The student will interpret data.
- The student will use the model to extrapolate.

Additional Objectives for Student Learning:

- Students will learn about changes in air temperature around the globe over time**.**
- **Students will become familiar with locations of other countries on the globe.**

Materials and Resources:

- Computers with internet access
- Access to spread sheet software or graphing calculators
- Presentation materials
- Attached handouts

Student/Teacher Actions:

- The teacher may use the following demonstration to show how patterns in climate change vary across the world. Note that Virginia remains roughly the same color over the duration of the demonstration, while the poles exhibit greater change.
  http://climate.nasa.gov/interactives/climate_time_machine
- Assign students to groups as appropriate for your class. Assign locations, or allow students to select a weather station from a native country or a place that they are interested in. Data is given for climate change for 17 different weather stations in handouts 8A through 8Q. Handout 8R is a blank page to include data for another location if the teacher chooses. A scoring sheet is provided on handout 8S.
  - Additional data may be taken from http://data.giss.nasa.gov/gistemp/station_data/
- Students will create a scatter plot and trend line for their given location. The teacher may elect to do this on graph paper, in a graphing calculator or in Excel. Some data sets are not complete due to collection methods. Students should omit years with incomplete data when making their scatter plots.

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- The students will create a visual model of their data to share with the class.

- The students will use their model to extrapolate.

- The students will present their information to the class.

- The teacher will lead a discussion about how temperature change varies by location and ask students to suggest why this might be true.

- The teacher may use a world map and allow students to place their findings on the map.

- Extensions:

    - Encourage students to use the web site to explore additional weather stations
    - Encourage students to research news stories about climate change near the station that they analyzed

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Name____ Date_______ HO#8A

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Surface Temperature Analysis

Dublin Airport, Ireland

The following data indicate the annual mean temperature in degrees Celsius at the Dublin Ireland Airport over a period of years. Complete the following tasks using the data on the back of this page.

Map courtesy National Geographic Education. National Geographic does not review or endorse content added to this background by others.

- Make a scatterplot of the data.
- Determine the equation of a model that fits the data and draw it on the scatterplot.
- Explain the meaning of the coefficients and constants in your equation.
- What does this data tell you?
- Use your model to predict air temperatures 5 years from now, 10 years from now and 15 years from now.
- How far into the future do you believe this model will be reasonable?
- Be prepared to explain the above information to the class.

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Year	Mean Temp.
1950	8.67
1951	7.83
1952	8.38
1953	8.83
1954	8.49
1955	8.59
1956	8.32
1957	9.07
1958	8.6
1959	9.33
1960	8.87
1961	9.01
1962	7.92
1963	7.84
1964	8.81
1965	8.17
1966	8.64
1967	8.71
1968	8.74
1969	8.5
1970	8.75

Year	Mean Temp.
1971	9.08
1972	8.64
1973	9
1974	8.27
1975	9.29
1976	9.1
1977	8.27
1978	8.87
1979	8.12
1980	8.61
1981	8.72
1982	8.52
1983	8.75
1984	8.79
1985	8.04
1986	7.87
1987	8.37
1988	8.86
1989	9.68
1990	9.45
1991	8.78

Year	Mean Temp.
1992	9.12
1993	8.79
1994	8.9
1995	9.81
1996	8.93
1997	9.49
1998	9.72
1999	9.75
2000	9.09
2001	9.18
2002	9.58
2003	9.75
2004	9.61
2005	9.78
2006	9.82
2007	9.93
2008	9.52
2009	9.62
2010	8.54
2011	9.4
2012	9.34

Retrieved from http://data.giss.nasa.gov/gistemp/station_data/

Name____ Date_______ HO#8B

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Surface Temperature Analysis

Allahabad, India

The following data indicate the annual mean temperature in degrees Celsius in Allahabad, India over a period of years. Complete the following tasks using the data on the back of this page.

Map courtesy National Geographic Education. National Geographic does not review or endorse content added to this background by others.

- Make a scatterplot of the data.
- Determine the equation of a model that fits the data and draw it on the scatterplot.
- Explain the meaning of the coefficients and constants in your equation.
- What does this data tell you?
- Use your model to predict air temperatures 5 years from now, 10 years from now and 15 years from now.
- How far into the future do you believe this model will be reasonable?
- Be prepared to explain the above information to the class.

Year	Mean Temp.
1950	----*
1951	----
1952	----
1953	----
1954	----
1955	----
1956	----
1957	----
1958	----
1959	16.22
1960	16.81
1961	16.07
1962	15.67
1963	16.83
1964	15.72
1965	15.43
1966	15.85
1967	16.17
1968	14.74
1969	15.65
1970	15.65

Year	Mean Temp.
1971	25.38
1972	26.44
1973	26.88
1974	26.42
1975	26.02
1976	25.81
1977	26.2
1978	25.91
1979	26.61
1980	26.35
1981	25.97
1982	25.75
1983	25.56
1984	26.03
1985	26.68
1986	25.89
1987	----
1988	26.49
1989	26.16
1990	26
1991	26.1

Year	Mean Temp.
1992	----
1993	----
1994	----
1995	26.43
1996	26.4
1997	25.89
1998	26.62
1999	26.64
2000	26.24
2001	26.12
2002	26.97
2003	26.23
2004	26.66
2005	26.88
2006	26.51
2007	25.59
2008	25.41
2009	27.13
2010	27.49
2011	26.54
2012	26.62

Retrieved from http://data.giss.nasa.gov/gistemp/station_data/

*---- indicates that data is not available

Name____ Date_______ HO#8C

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Surface Temperature Analysis

Corvalis, Oregon

The following data indicate the annual mean temperature in degrees Celsius in Corvalis, Oregon over a period of years. Complete the following tasks using the data on the back of this page.

Map courtesy National Geographic Education. National Geographic does not review or endorse content added to this background by others.

- Make a scatterplot of the data.
- Determine the equation of a model that fits the data and draw it on the scatterplot.
- Explain the meaning of the coefficients and constants in your equation.
- What does this data tell you?
- Use your model to predict air temperatures 5 years from now, 10 years from now and 15 years from now.
- How far into the future do you believe this model will be reasonable?
- Be prepared to explain the above information to the class.

Year	Mean Temp.
1950	10.55
1951	11.46
1952	10.94
1953	11.48
1954	10.82
1955	10
1956	10.88
1957	10.92
1958	12.74
1959	11.45
1960	10.95
1961	11.59
1962	10.94
1963	11.21
1964	10.43
1965	11.64
1966	11.38
1967	12.14
1968	11.4
1969	10.88
1970	11.44

Year	Mean Temp.
1971	10.64
1972	11.59
1973	11.19
1974	11.46
1975	11.02
1976	11.13
1977	10.98
1978	11.83
1979	11.18
1980	11.47
1981	11.7
1982	11.11
1983	11.74
1984	10.98
1985	10.58
1986	11.68
1987	12.24
1988	11.68
1989	11.39
1990	11.86
1991	11.4

Year	Mean Temp.
1992	12.98
1993	11.03
1994	11.59
1995	12.43
1996	11.81
1997	12.23
1998	12.25
1999	11.51
2000	11.58
2001	11.48
2002	11.68
2003	12.54
2004	12.17
2005	11.94
2006	12.07
2007	11.62
2008	11.22
2009	11.51
2010	11.48
2011	11.4
2012	11.36

Retrieved from http://data.giss.nasa.gov/gistemp/station_data/

Name____ Date_______ HO#8D

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Surface Temperature Analysis

Mazatlan, Sinaloa, Mexico

The following data indicate the annual mean temperature in degrees Celsius in Mazatlan, Sinaloa, Mexico over a period of years. Complete the following tasks using the data on the back of this page.

Map courtesy National Geographic Education. National Geographic does not review or endorse content added to this background by others.

- Make a scatterplot of the data.
- Determine the equation of a model that fits the data and draw it on the scatterplot.
- Explain the meaning of the coefficients and constants in your equation.
- What does this data tell you?
- Use your model to predict air temperatures 5 years from now, 10 years from now and 15 years from now.
- How far into the future do you believe this model will be reasonable?
- Be prepared to explain the above information to the class.

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Year	Mean Temp.
1950	24
1951	23.85
1952	23.83
1953	23.73
1954	23.91
1955	23.18
1956	23.53
1957	----
1958	----
1959	24.21
1960	23.08
1961	23.38
1962	23.46
1963	24.09
1964	22.87
1965	22.36
1966	23.56
1967	23.29
1968	22.97
1969	23.61
1970	23.39

Year	Mean Temp.
1971	22.89
1972	23.6
1973	23.12
1974	22.88
1975	22.38
1976	----
1977	----
1978	23.89
1979	23.08
1980	23.48
1981	23.67
1982	23.97
1983	24.2
1984	23.76
1985	23.5
1986	23.89
1987	24.04
1988	23.59
1989	23.66
1990	24.36
1991	----

Year	Mean Temp.
1992	----
1993	----
1994	24.5
1995	24.03
1996	24.36
1997	----
1998	24.29
1999	23.82
2000	23.57
2001	23.94
2002	24.34
2003	24.22
2004	24.55
2005	23.87
2006	24.27
2007	24.19
2008	23.61
2009	24.68
2010	24.26
2011	24.37
2012	24.8

Retrieved from http://data.giss.nasa.gov/gistemp/station_data/

*---- indicates that data is not available

Name____ Date_______ HO#8E

Goddard Institute for Space Studies

Surface Temperature Analysis

Curitiba, Parana, Brazil

The following data indicate the annual mean temperature in degrees Celsius in Curitiba, Parana, Brazil over a period of years. Complete the following tasks using the data on the back of this page.

Map courtesy National Geographic Education. National Geographic does not review or endorse content added to this background by others.

- Make a scatterplot of the data.
- Determine the equation of a model that fits the data and draw it on the scatterplot.
- Explain the meaning of the coefficients and constants in your equation.
- What does this data tell you?
- Use your model to predict air temperatures 5 years from now, 10 years from now and 15 years from now.
- How far into the future do you believe this model will be reasonable?
- Be prepared to explain the above information to the class.

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Year	Mean Temp.
1950	17.03
1951	16.53
1952	17.14
1953	17.27
1954	17.53
1955	17
1956	16.77
1957	17.1
1958	18.16
1959	18.4
1960	17.54
1961	18.38
1962	16.72
1963	18.38
1964	17.22
1965	17.65
1966	17.88
1967	18.23
1968	16.72
1969	17.62
1970	17.14

Year	Mean Temp.
1971	17.12
1972	17.11
1973	----
1974	17.3
1975	17.4
1976	----
1977	----
1978	17.52
1979	17.12
1980	17.83
1981	17.78
1982	17.73
1983	17.76
1984	18.25
1985	17.84
1986	18.25
1987	17.72
1988	17.43
1989	17.22
1990	17.69
1991	17.76

Year	Mean Temp.
1992	----
1993	17.97
1994	17.98
1995	18.52
1996	17.71
1997	18.01
1998	17.84
1999	17.24
2000	17.61
2001	18.45
2002	19.03
2003	18.17
2004	17.41
2005	18.32
2006	18.12
2007	18.32
2008	17.48
2009	17.89
2010	17.88
2011	17.28
2012	17.9

Retrieved from http://data.giss.nasa.gov/gistemp/station_data/

*---- indicates that data is not available

Name____ Date_______ HO#8F

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Surface Temperature Analysis

Cartwright, Newfoundland, Canada

The following data indicate the annual mean temperature in degrees Celsius Cartwright, Newfoundland, Canada over a period of years. Complete the following tasks using the data on the back of this page.

Map courtesy National Geographic Education. National Geographic does not review or endorse content added to this background by others.

- Make a scatterplot of the data.
- Determine the equation of a model that fits the data and draw it on the scatterplot.
- Explain the meaning of the coefficients and constants in your equation.
- What does this data tell you?
- Use your model to predict air temperatures 5 years from now, 10 years from now and 15 years from now.
- How far into the future do you believe this model will be reasonable?
- Be prepared to explain the above information to the class.

Year	Mean Temp.
1950	0.05
1951	2.2
1952	1.53
1953	1.41
1954	0.36
1955	1.83
1956	1.02
1957	-0.67
1958	2.25
1959	0.57
1960	1.86
1961	0.78
1962	0.69
1963	0.46
1964	0.07
1965	0.29
1966	2.03
1967	0.52
1968	0.68
1969	1.5
1970	1.52

Year	Mean Temp.
1971	0.78
1972	-2.12
1973	-0.16
1974	-0.85
1975	-0.27
1976	-0.37
1977	1.13
1978	-0.49
1979	1.46
1980	0.63
1981	1.61
1982	-0.32
1983	-0.24
1984	-0.5
1985	-0.89
1986	-1.02
1987	0.09
1988	0.23
1989	-1.03
1990	----
1991	-1.9

Year	Mean Temp.
1992	-1.95
1993	-1.94
1994	-0.67
1995	-0.67
1996	0.52
1997	-0.2
1998	1.04
1999	1.31
2000	0.63
2001	----
2002	-0.26
2003	0.43
2004	1.73
2005	1.24
2006	2.42
2007	0.53
2008	0.12
2009	-0.01
2010	3.09
2011	1.66
2012	1.46

Retrieved from http://data.giss.nasa.gov/gistemp/station_data/

*---- indicates that data is not available

Name____ Date_______ HO#8G

Goddard Institute for Space Studies

Surface Temperature Analysis

Eureka, Northwest Territory, Canada

The following data indicate the annual mean temperature in degrees Celsius in Eureka, Northwest Territory, Canada over a period of years. Complete the following tasks using the data on the back of this page.

Map courtesy National Geographic Education. National Geographic does not review or endorse content added to this background by others.

- Make a scatterplot of the data.
- Determine the equation of a model that fits the data and draw it on the scatterplot.
- Explain the meaning of the coefficients and constants in your equation.
- What does this data tell you?
- Use your model to predict air temperatures 5 years from now, 10 years from now and 15 years from now.
- How far into the future do you believe this model will be reasonable?
- Be prepared to explain the above information to the class.

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Year	Mean Temp.
1950	-20.18
1951	-18.93
1952	-19.28
1953	-18.65
1954	-18.81
1955	-18.91
1956	-20.22
1957	-19.78
1958	-19
1959	-19.13
1960	-18.12
1961	-20.63
1962	-18.29
1963	-19.15
1964	-20.14
1965	-18.53
1966	-20.16
1967	-18.55
1968	----
1969	-20.18
1970	-19.89

Year	Mean Temp.
1971	-19.75
1972	-21.54
1973	-21.07
1974	-20.94
1975	-20.51
1976	-20.66
1977	-19.36
1978	-20.12
1979	-20.81
1980	-20.2
1981	-17.93
1982	-19.67
1983	-19.6
1984	-20.74
1985	-20.23
1986	-20
1987	----
1988	-16.89
1989	-20.39
1990	-19.42
1991	-18.43

Year	Mean Temp.
1992	-20.73
1993	-18.64
1994	-17.87
1995	-18.3
1996	-19.22
1997	-18.82
1998	-17.38
1999	-18.64
2000	-19.88
2001	-18.61
2002	-17.92
2003	-17.51
2004	-18.72
2005	-17.34
2006	-16.83
2007	-17.77
2008	-18.2
2009	-17.98
2010	-16.19
2011	-16.43
2012	-17.88

Retrieved from http://data.giss.nasa.gov/gistemp/station_data/

*---- indicates that data is not available

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Name____ Date_______ HO#8H

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Surface Temperature Analysis

Ceduna, Australia

The following data indicate the annual mean temperature in degrees Celsius Ceduna, Australia over a period of years. Complete the following tasks using the data on the back of this page.

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- Make a scatterplot of the data.
- Determine the equation of a model that fits the data and draw it on the scatterplot.
- Explain the meaning of the coefficients and constants in your equation.
- What does this data tell you?
- Use your model to predict air temperatures 5 years from now, 10 years from now and 15 years from now.
- How far into the future do you believe this model will be reasonable?
- Be prepared to explain the above information to the class.

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Year	Mean Temp.
1950	16.38
1951	17.15
1952	16.09
1953	16.5
1954	16.37
1955	16.96
1956	16.15
1957	16.49
1958	16.27
1959	16.73
1960	15.98
1961	17.35
1962	16.89
1963	16.55
1964	16.27
1965	16.82
1966	16.84
1967	16.98
1968	17.24
1969	16.46
1970	16.36

Year	Mean Temp.
1971	16.64
1972	16.61
1973	17.56
1974	17.13
1975	17.17
1976	16.47
1977	17.09
1978	16.63
1979	17
1980	17.15
1981	17.57
1982	17.34
1983	16.97
1984	16.67
1985	16.99
1986	16.53
1987	16.51
1988	17.22
1989	16.72
1990	17.44
1991	17.52

Year	Mean Temp.
1992	16.43
1993	17
1994	16.93
1995	17.09
1996	16.86
1997	16.82
1998	16.89
1999	17.35
2000	17.53
2001	17.13
2002	16.57
2003	17.08
2004	17.27
2005	17.49
2006	17.17
2007	17.82
2008	17.81
2009	17.91
2010	17.32
2011	17.36
2012	17.38

Retrieved from http://data.giss.nasa.gov/gistemp/station_data/

*---- indicates that data is not available

Name____ Date_______ HO#8I

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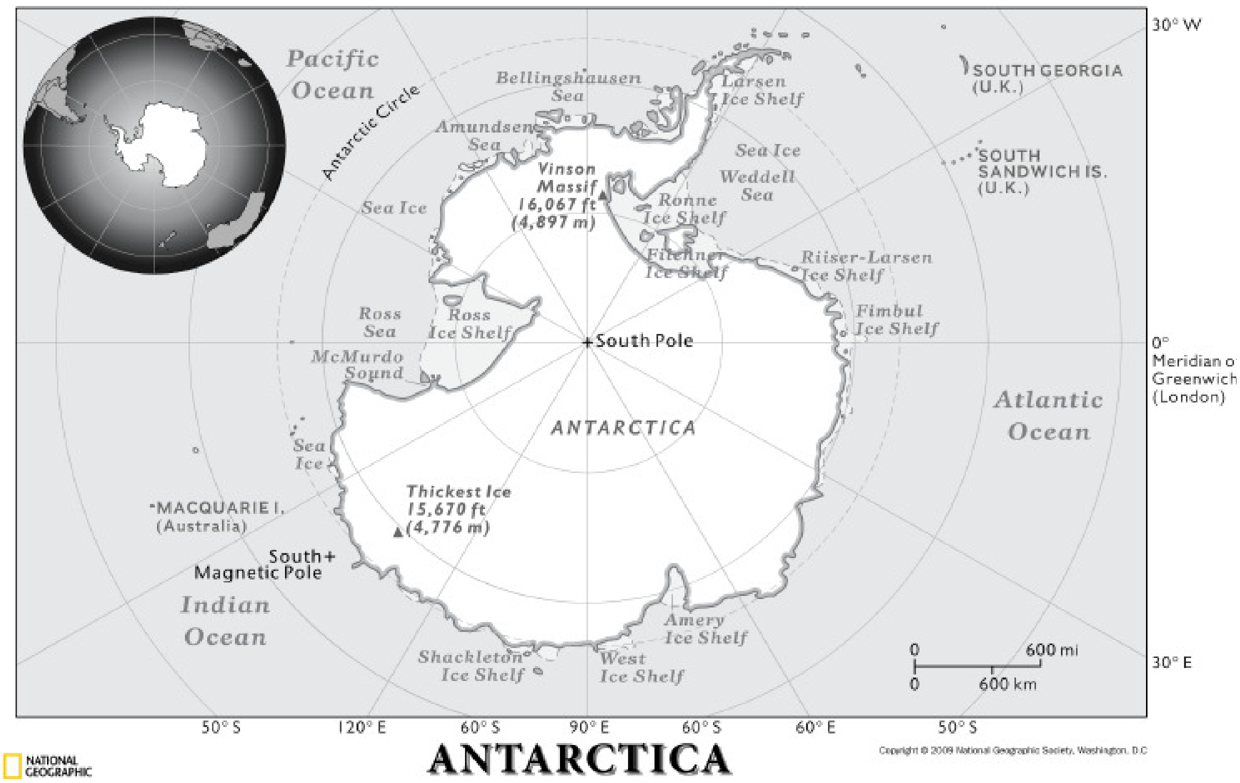
Surface Temperature Analysis

McMurdo Station, Antarctica

The following data indicate the annual mean temperature in degrees Celsius at the McMurdo Station, Antarctica over a period of years. Complete the following tasks using the data on the back of this page.



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- Make a scatterplot of the data.
- Determine the equation of a model that fits the data and draw it on the scatterplot.
- Explain the meaning of the coefficients and constants in your equation.
- What does this data tell you?
- Use your model to predict air temperatures 5 years from now, 10 years from now and 15 years from now.
- How far into the future do you believe this model will be reasonable?
- Be prepared to explain the above information to the class.

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Year	Mean Temp.
1950	----
1951	----
1952	----
1953	----
1954	----
1955	----
1956	-16.74
1957	-16.94
1958	-18.19
1959	-18.57
1960	-18.13
1961	-17.06
1962	-18.73
1963	-17.96
1964	-17.43
1965	-17.51
1966	-16.4
1967	-16.49
1968	-17.75
1969	-17.55
1970	-16.03

Year	Mean Temp.
1971	-15.93
1972	-15.19
1973	-16.3
1974	-16.95
1975	-17.22
1976	-18.45
1977	-17.48
1978	-18.48
1979	-18.02
1980	-16.28
1981	-16.89
1982	-18.21
1983	-16.56
1984	-15.72
1985	-17.57
1986	-17.32
1987	-15.37
1988	-15.13
1989	-18.46
1990	-17.75
1991	-15.97

Year	Mean Temp.
1992	----
1993	-17.08
1994	-17.46
1995	-17.49
1996	-15.18
1997	-15.69
1998	----
1999	-15.65
2000	-16.52
2001	-16.91
2002	-16.66
2003	-16.45
2004	-18.31
2005	-16.85
2006	-16.95
2007	-15.03
2008	-16.01
2009	-16.23
2010	-16.25
2011	-14.07
2012	-15.56

Retrieved from http://data.giss.nasa.gov/gistemp/station_data/

*---- indicates that data is not available

Name____ Date_______ HO#8J

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Surface Temperature Analysis

Austin, Texas

The following data indicate the annual mean temperature in degrees Celsius in Austin, Texas over a period of years. Complete the following tasks using the data on the back of this page.

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- Make a scatterplot of the data.
- Determine the equation of a model that fits the data and draw it on the scatterplot.
- Explain the meaning of the coefficients and constants in your equation.
- What does this data tell you?
- Use your model to predict air temperatures 5 years from now, 10 years from now and 15 years from now.
- How far into the future do you believe this model will be reasonable?
- Be prepared to explain the above information to the class.

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Year	Mean Temp.
1950	21.34
1951	21.27
1952	21
1953	21.37
1954	21.56
1955	21.38
1956	21.46
1957	20.63
1958	20.34
1959	19.93
1960	20.27
1961	19.97
1962	20.95
1963	21.48
1964	20.43
1965	20.47
1966	20.27
1967	20.93
1968	19.48
1969	20.3
1970	19.74

Year	Mean Temp.
1971	21.49
1972	21.13
1973	19.99
1974	20.47
1975	20.14
1976	19.69
1977	20.65
1978	20.12
1979	19.25
1980	20.48
1981	20.85
1982	20.83
1983	19.87
1984	20.38
1985	20.95
1986	21.14
1987	20.43
1988	20.96
1989	21.22
1990	21.6
1991	20.77

Year	Mean Temp.
1992	20.85
1993	20.7
1994	21.38
1995	20.9
1996	19.76
1997	20.42
1998	22.13
1999	----
2000	----
2001	20.61
2002	20.97
2003	20.78
2004	21.27
2005	21.91
2006	22.28
2007	20.85
2008	21.32
2009	21.92
2010	----
2011	22.33
2012	21.77

Retrieved from http://data.giss.nasa.gov/gistemp/station_data/

*---- indicates that data is not available

Name____ Date_______ HO#8K

Goddard Institute for Space Studies

Surface Temperature Analysis

Fairbanks International Airport, Alaska

The following data indicate the annual mean temperature in degrees Celsius at the Fairbanks International Airport, Alaska over a period of years. Complete the following tasks using the data on the back of this page.

Map courtesy National Geographic Education. National Geographic does not review or endorse content added to this background by others.

- Make a scatterplot of the data.
- Determine the equation of a model that fits the data and draw it on the scatterplot.
- Explain the meaning of the coefficients and constants in your equation.
- What does this data tell you?
- Use your model to predict air temperatures 5 years from now, 10 years from now and 15 years from now.
- How far into the future do you believe this model will be reasonable?
- Be prepared to explain the above information to the class.

Developed by Dr. Agida Manizade & Dr. Laura Jacobsen, Radford University MSP project
in collaboration with
Mr. Michael Bolling, Virginia Department of Education

Year	Mean Temp.
1950	-3.26
1951	-3.38
1952	-3.05
1953	-2.38
1954	-2.9
1955	-4.97
1956	-4.68
1957	-1.58
1958	-2.47
1959	-3.91
1960	-2.88
1961	-3.1
1962	-2.78
1963	-3.09
1964	-3.44
1965	-4.98
1966	-4.58
1967	-3.32
1968	-2.53
1969	-3.47
1970	-1.37

Year	Mean Temp.
1971	-4.46
1972	-4.05
1973	-2.46
1974	-3.1
1975	-3.08
1976	-2.65
1977	-1.53
1978	-1.62
1979	-1.77
1980	-0.97
1981	-0.72
1982	-3.13
1983	-1.41
1984	-2.52
1985	-2.99
1986	-1.71
1987	-0.17
1988	-1.57
1989	-2.29
1990	-2.18
1991	-1.89

Year	Mean Temp.
1992	-3.53
1993	-0.6
1994	-2.05
1995	-1.99
1996	-3.85
1997	-2.1
1998	-1.92
1999	-4.36
2000	-2.72
2001	-1.23
2002	-1.4
2003	-0.77
2004	-1.9
2005	-1.68
2006	-3.17
2007	-2.25
2008	-3.11
2009	-2.47
2010	-1.1
2011	-3.34
2012	-3.37

Retrieved from http://data.giss.nasa.gov/gistemp/station_data/

*---- indicates that data is not available

Name____ Date_______ HO#8L

Goddard Institute for Space Studies

Surface Temperature Analysis

Tacloban, Philippines

The following data indicate the annual mean temperature in degrees Celsius in Tacloban, Philippines over a period of years. Complete the following tasks using the data on the back of this page.

Map courtesy National Geographic Education. National Geographic does not review or endorse content added to this background by others.

- Make a scatterplot of the data.
- Determine the equation of a model that fits the data and draw it on the scatterplot.
- Explain the meaning of the coefficients and constants in your equation.
- What does this data tell you?
- Use your model to predict air temperatures 5 years from now, 10 years from now and 15 years from now.
- How far into the future do you believe this model will be reasonable?
- Be prepared to explain the above information to the class.

Year	Mean Temp.
1950	----
1951	26.81
1952	26.83
1953	26.92
1954	26.83
1955	26.6
1956	26.5
1957	26.92
1958	26.83
1959	26.72
1960	26.89
1961	26.67
1962	26.42
1963	26.55
1964	26.88
1965	26.49
1966	26.98
1967	26.7
1968	26.78
1969	26.9
1970	----

Year	Mean Temp.
1971	----
1972	----
1973	26.93
1974	26.66
1975	26.65
1976	26.43
1977	27.15
1978	26.99
1979	27.18
1980	26.75
1981	27.12
1982	27.2
1983	27.36
1984	27.06
1985	27.41
1986	27.14
1987	27.26
1988	27.53
1989	26.93
1990	27.03
1991	26.81

Year	Mean Temp.
1992	----
1993	27.04
1994	27.28
1995	27.23
1996	27.11
1997	27.18
1998	28
1999	27.17
2000	27.38
2001	----
2002	----
2003	27.35
2004	27.36
2005	27.51
2006	27.54
2007	27.55
2008	27.24
2009	27.74
2010	27.83
2011	27.4
2012	27.89

Retrieved from http://data.giss.nasa.gov/gistemp/station_data/

*---- indicates that data is not available

Name____ Date_______ HO#8M

Goddard Institute for Space Studies

Surface Temperature Analysis

Maebashi, Japan

The following data indicate the annual mean temperature in degrees Celsius in Maebashi, Japan over a period of years. Complete the following tasks using the data on the back of this page.

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- Make a scatterplot of the data.
- Determine the equation of a model that fits the data and draw it on the scatterplot.
- Explain the meaning of the coefficients and constants in your equation.
- What does this data tell you?
- Use your model to predict air temperatures 5 years from now, 10 years from now and 15 years from now.
- How far into the future do you believe this model will be reasonable?
- Be prepared to explain the above information to the class.

Developed by Dr. Agida Manizade & Dr. Laura Jacobsen, Radford University MSP project
in collaboration with
Mr. Michael Bolling, Virginia Department of Education

Year	Mean Temp.
1950	14.61
1951	13.88
1952	14.19
1953	13.75
1954	14.28
1955	14.72
1956	14.32
1957	13.94
1958	14.57
1959	14.95
1960	14.71
1961	14.97
1962	14.41
1963	13.98
1964	14.45
1965	13.93
1966	14.4
1967	14.36
1968	13.97
1969	14.57
1970	13.91

Year	Mean Temp.
1971	13.82
1972	14.49
1973	14.43
1974	13.43
1975	14.31
1976	13.94
1977	----
1978	----
1979	15.31
1980	14.01
1981	13.65
1982	14.36
1983	14.31
1984	13.41
1985	14.43
1986	13.62
1987	15.04
1988	13.96
1989	14.72
1990	15.4
1991	15.06

Year	Mean Temp.
1992	14.67
1993	14.12
1994	15.56
1995	14.81
1996	14.15
1997	15.13
1998	15.34
1999	15.36
2000	15.03
2001	14.88
2002	14.95
2003	14.29
2004	15.58
2005	14.88
2006	14.63
2007	15.38
2008	14.83
2009	15.12
2010	15.41
2011	15.07
2012	14.69

Retrieved from http://data.giss.nasa.gov/gistemp/station_data/

*---- indicates that data is not available

Name____ Date_______ HO#8N

Goddard Institute for Space Studies

Surface Temperature Analysis

Moscow, Russia

The following data indicate the annual mean temperature in degrees Celsius in Moscow, Russia over a period of years. Complete the following tasks using the data on the back of this page.

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- Make a scatterplot of the data.
- Determine the equation of a model that fits the data and draw it on the scatterplot.
- Explain the meaning of the coefficients and constants in your equation.
- What does this data tell you?
- Use your model to predict air temperatures 5 years from now, 10 years from now and 15 years from now.
- How far into the future do you believe this model will be reasonable?
- Be prepared to explain the above information to the class.

Developed by Dr. Agida Manizade & Dr. Laura Jacobsen, Radford University MSP project
in collaboration with
Mr. Michael Bolling, Virginia Department of Education

Year	Mean Temp.
1950	4.52
1951	4.38
1952	5.38
1953	4.67
1954	4.66
1955	5.1
1956	2.34
1957	6.06
1958	4.83
1959	5.11
1960	4.14
1961	6.72
1962	5.16
1963	4.03
1964	4.6
1965	3.91
1966	6.03
1967	5.29
1968	4.01
1969	3.42
1970	4.47

Year	Mean Temp.
1971	4.79
1972	5.51
1973	6.37
1974	5.74
1975	6.69
1976	3.11
1977	5.3
1978	4.22
1979	4.21
1980	3.83
1981	6.27
1982	4.98
1983	6.33
1984	5.4
1985	3.55
1986	4.75
1987	2.95
1988	5.4
1989	6.8
1990	5.91
1991	5.9

Year	Mean Temp.
1992	5.61
1993	4.28
1994	4.7
1995	6.38
1996	4.91
1997	4.74
1998	4.64
1999	5.82
2000	6.28
2001	6.18
2002	5.94
2003	4.46
2004	5.6
2005	6.05
2006	4.9
2007	7.13
2008	7.19
2009	6.47
2010	6.51
2011	6.08
2012	6.53

Retrieved from http://data.giss.nasa.gov/gistemp/station_data/

*---- indicates that data is not available

Name____ Date_______ HO#8O

Goddard Institute for Space Studies

Surface Temperature Analysis

Kharga, Egypt

The following data indicate the annual mean temperature in degrees Celsius in Kharga, Egypt over a period of years. Complete the following tasks using the data on the back of this page.

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- Make a scatterplot of the data.
- Determine the equation of a model that fits the data and draw it on the scatterplot.
- Explain the meaning of the coefficients and constants in your equation.
- What does this data tell you?
- Use your model to predict air temperatures 5 years from now, 10 years from now and 15 years from now.
- How far into the future do you believe this model will be reasonable?
- Be prepared to explain the above information to the class.

Developed by Dr. Agida Manizade & Dr. Laura Jacobsen, Radford University MSP project
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Mr. Michael Bolling, Virginia Department of Education

Year	Mean Temp.
1950	----
1951	25.18
1952	24.86
1953	24.88
1954	24.13
1955	25.38
1956	24.55
1957	24.59
1958	24.77
1959	24.15
1960	24.95
1961	24.23
1962	25.03
1963	----
1964	----
1965	24.54
1966	25.07
1967	23.88
1968	24.58
1969	25.01
1970	24.48

Year	Mean Temp.
1971	24.18
1972	24.49
1973	24.32
1974	24.36
1975	23.92
1976	24.79
1977	24.38
1978	24.38
1979	25.43
1980	24.43
1981	24.28
1982	24.12
1983	23.56
1984	24.71
1985	24.65
1986	24.78
1987	24.2
1988	24.83
1989	24.52
1990	----
1991	----

Year	Mean Temp.
1992	----
1993	----
1994	----
1995	----
1996	----
1997	24.45
1998	25.06
1999	25.56
2000	24.75
2001	25.32
2002	25.73
2003	24.88
2004	25.14
2005	25.08
2006	25.45
2007	25.14
2008	25.53
2009	25.39
2010	26.94
2011	25.14
2012	25.57

Retrieved from http://data.giss.nasa.gov/gistemp/station_data/

*---- indicates that data is not available

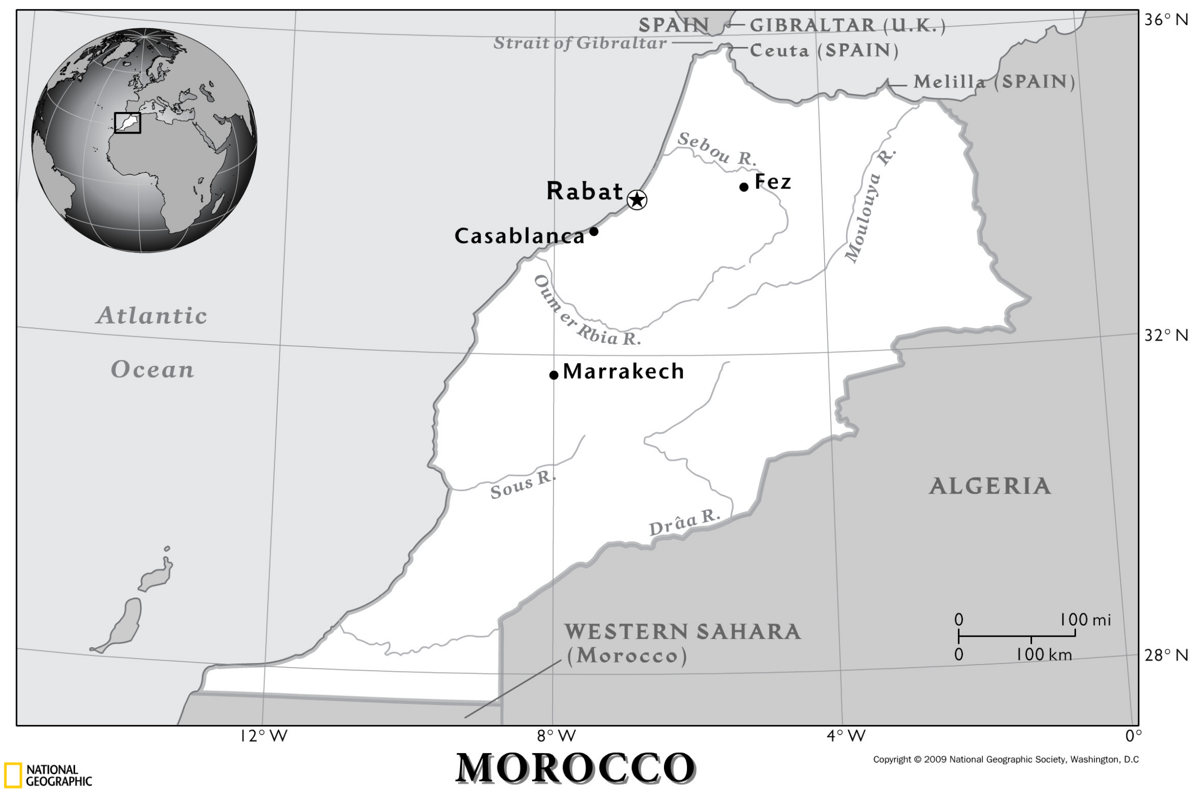
Name____ Date_______ HO#8P

Goddard Institute for Space Studies

Surface Temperature Analysis

Casablanca, Morocco (Western Africa)

The following data indicate the annual mean temperature in degrees Celsius in Casablanca, Morocco (Western Africa) over a period of years. Complete the following tasks using the data on the back of this page.



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- Make a scatterplot of the data.
- Determine the equation of a model that fits the data and draw it on the scatterplot.
- Explain the meaning of the coefficients and constants in your equation.
- What does this data tell you?
- Use your model to predict air temperatures 5 years from now, 10 years from now and 15 years from now.
- How far into the future do you believe this model will be reasonable?
- Be prepared to explain the above information to the class.

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in collaboration with
Mr. Michael Bolling, Virginia Department of Education

Year	Mean Temp.
1950	17.34
1951	16.81
1952	17.06
1953	17.41
1954	16.85
1955	18.35
1956	16.9
1957	17.02
1958	17.38
1959	17.35
1960	17.57
1961	17.79
1962	17.76
1963	17.57
1964	17.76
1965	17.25
1966	17.53
1967	17.23
1968	17.28
1969	17.71
1970	17.6

Year	Mean Temp.
1971	17.07
1972	16.54
1973	17.16
1974	16.8
1975	17.09
1976	17.14
1977	17.32
1978	17.62
1979	17.71
1980	17.64
1981	----
1982	----
1983	18.22
1984	17.53
1985	17.79
1986	17.26
1987	18
1988	17.92
1989	18.32
1990	18.03
1991	17.4

Year	Mean Temp.
1992	17.74
1993	17.51
1994	17.51
1995	----
1996	18.38
1997	19.13
1998	18.65
1999	17.97
2000	18.22
2001	18.72
2002	18.45
2003	18.86
2004	18.48
2005	18.11
2006	18.49
2007	17.87
2008	17.68
2009	18.15
2010	18.8
2011	18.96
2012	18.31

Retrieved from http://data.giss.nasa.gov/gistemp/station_data/

*---- indicates that data is not available

Name____ Date_______ HO#8Q

Goddard Institute for Space Studies

Surface Temperature Analysis

Calvinia, South Africa

The following data indicate the annual mean temperature in degrees Celsius in Calvinia, South Africa over a period of years. Complete the following tasks using the data on the back of this page.

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- Make a scatterplot of the data.
- Determine the equation of a model that fits the data and draw it on the scatterplot.
- Explain the meaning of the coefficients and constants in your equation.
- What does this data tell you?
- Use your model to predict air temperatures 5 years from now, 10 years from now and 15 years from now.
- How far into the future do you believe this model will be reasonable?
- Be prepared to explain the above information to the class.

Developed by Dr. Agida Manizade & Dr. Laura Jacobsen, Radford University MSP project
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Mr. Michael Bolling, Virginia Department of Education

Year	Mean Temp.
1950	----
1951	----
1952	----
1953	----
1954	----
1955	----
1956	----
1957	----
1958	----
1959	16.22
1960	16.81
1961	16.07
1962	15.67
1963	16.83
1964	15.72
1965	15.43
1966	15.85
1967	16.17
1968	14.74
1969	15.65
1970	15.65

Year	Mean Temp.
1971	15.53
1972	16.76
1973	16.18
1974	15.94
1975	15.47
1976	15.55
1977	15.49
1978	15.67
1979	16.07
1980	16.25
1981	15.92
1982	15.96
1983	15.88
1984	16.61
1985	16.49
1986	16.02
1987	15.85
1988	15.93
1989	----
1990	----
1991	15.87

Year	Mean Temp.
1992	15.76
1993	16.61
1994	16.4
1995	----
1996	----
1997	15.72
1998	16.2
1999	17.22
2000	16.37
2001	16.14
2002	15.73
2003	16.21
2004	16.47
2005	16.49
2006	16.82
2007	16.2
2008	16.54
2009	16.57
2010	16.81
2011	16.54
2012	16.08

Retrieved from http://data.giss.nasa.gov/gistemp/station_data/

*---- indicates that data is not available

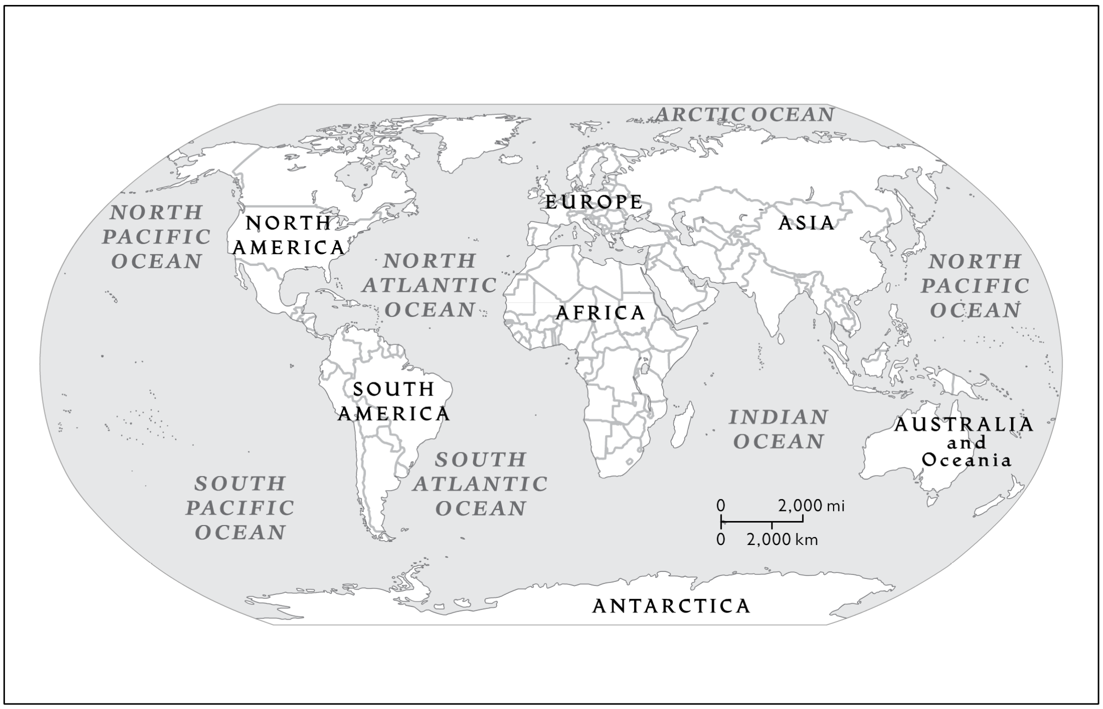
Name____ Date_______ HO#8R

Goddard Institute for Space Studies

Surface Temperature Analysis

____

The following data indicate the annual mean temperature in degrees Celsius in ______________ over a period of years. Complete the following tasks using the data on the back of this page.



THE WORLD

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- Make a scatterplot of the data.
- Determine the equation of a model that fits the data and draw it on the scatterplot.
- Explain the meaning of the coefficients and constants in your equation.
- What does this data tell you?
- Use your model to predict air temperatures 5 years from now, 10 years from now and 15 years from now.
- How far into the future do you believe this model will be reasonable?
- Be prepared to explain the above information to the class.

Year	Mean Temp.

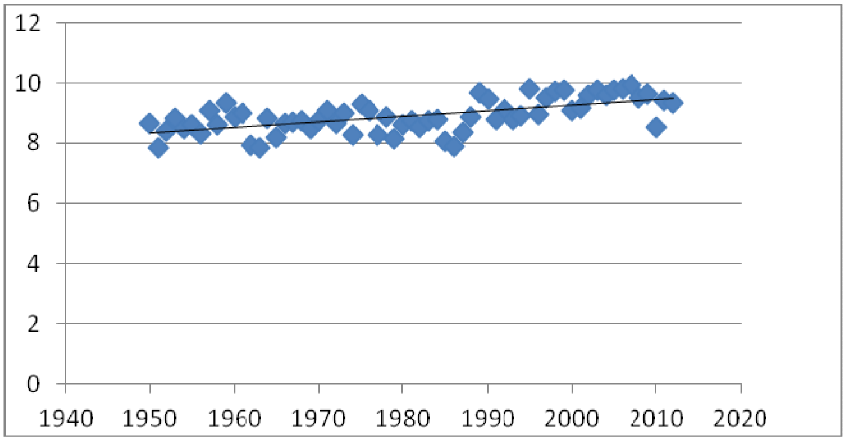
Year	Mean Temp.

Year	Mean Temp.

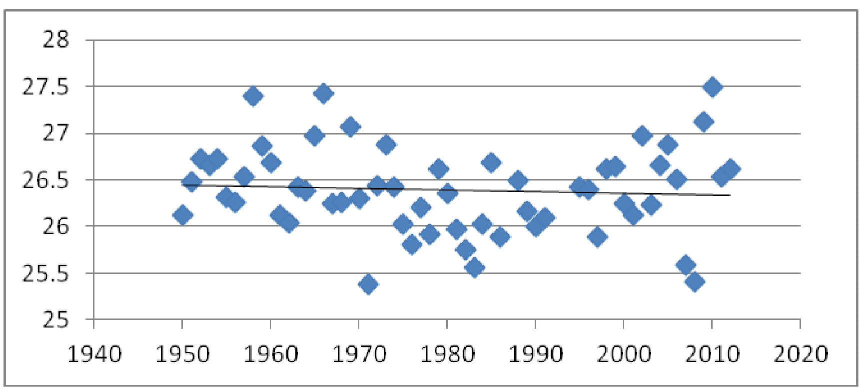
Retrieved from http://data.giss.nasa.gov/gistemp/station_data/

Answer Keys to HO#8_

HO# 8A Dublin Airport, Ireland   y =.0186x – 27.9356, r^2= .38



HO#8B Allahabad, India   y = -0.0018x + 29.9103 r^2 = 0.005122



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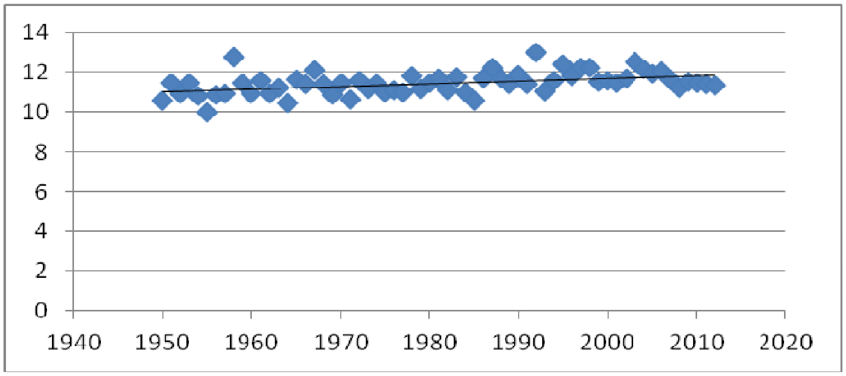
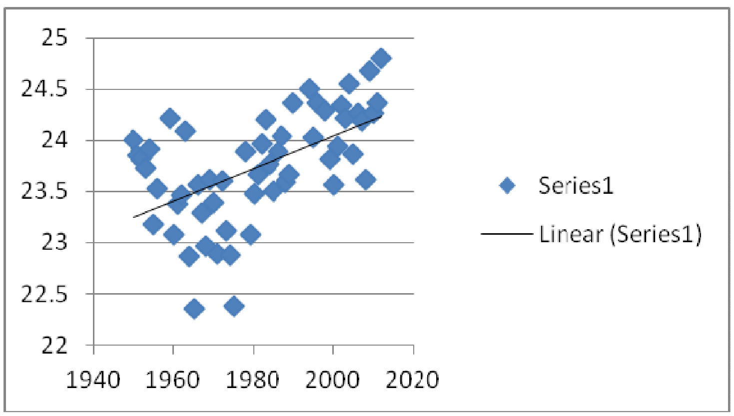
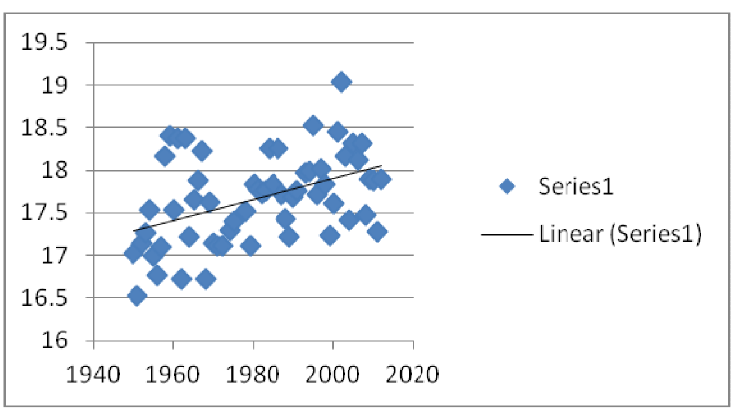
HO#8C Corvalis, Oregon $y=0.0135x- 15.2112$ $r^2= .20$



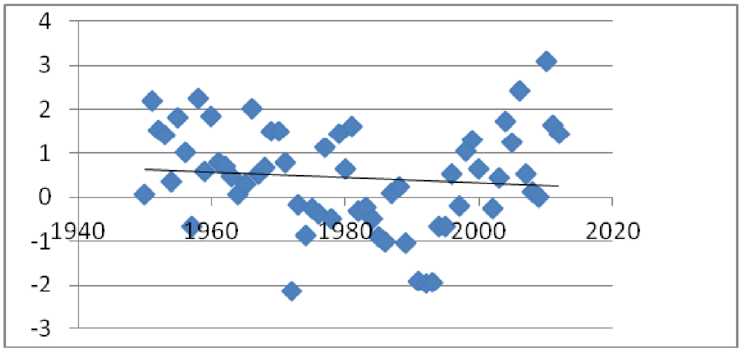
HO#8D Mazatlan, Sinaloa, Mexico $y = 0.0159x-7.8016$ $r^2 = .30$



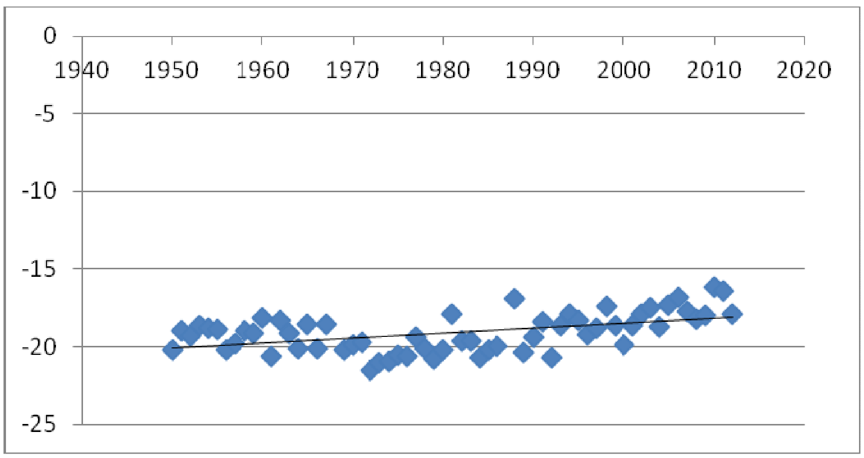
HO#8E Curitiba, Parana, Brazil $y=0.0123x – 6.6667$ $r^2 = .20$



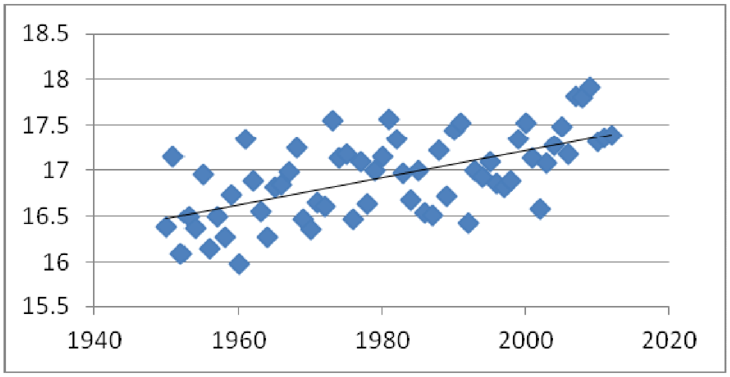
HO#8F Cartwright, Newfoundland, Canada y=0.0060x+12.4094 r^2 = .009



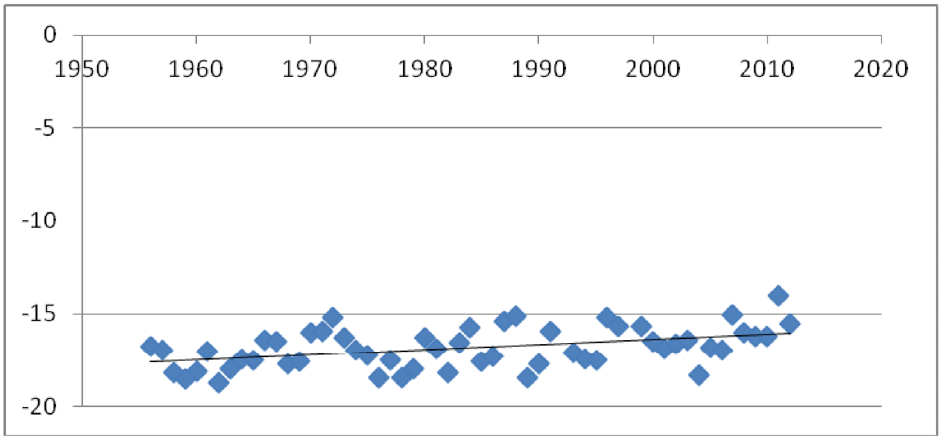
HO#8G Eureka, Northwest Territory, Canada y = .0325x-83.4954 r^2=.24



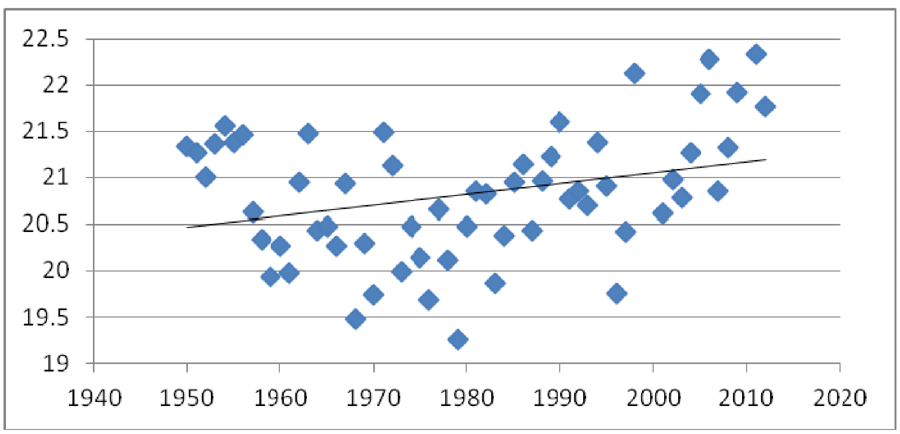
HO#8H Ceduna, Australia y=0.0149x-12.5821 r^2=.37



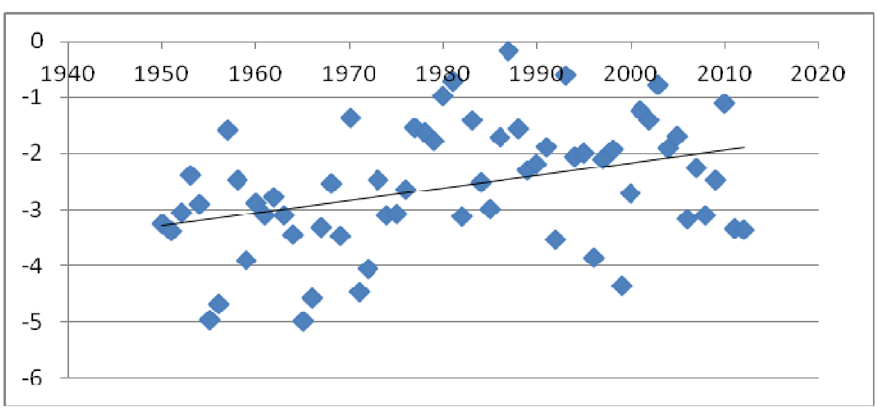
HO#8I McMurdo Station, Antarctica y=.0283x-72.9372 r^2=.20



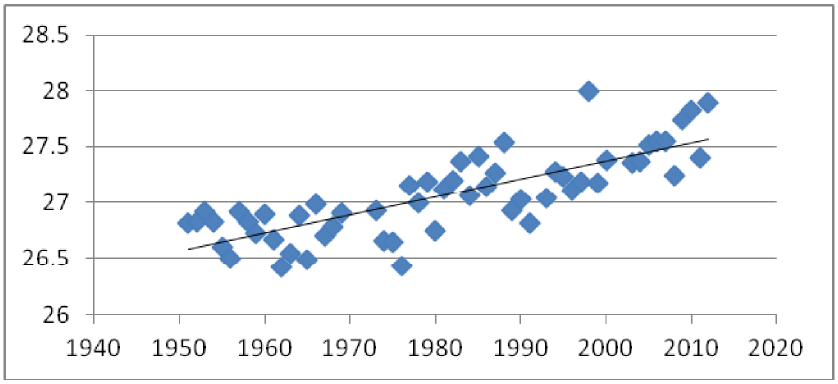
HO#8J Austin, Texas y=0.0116x-2.2433 r^2=.09



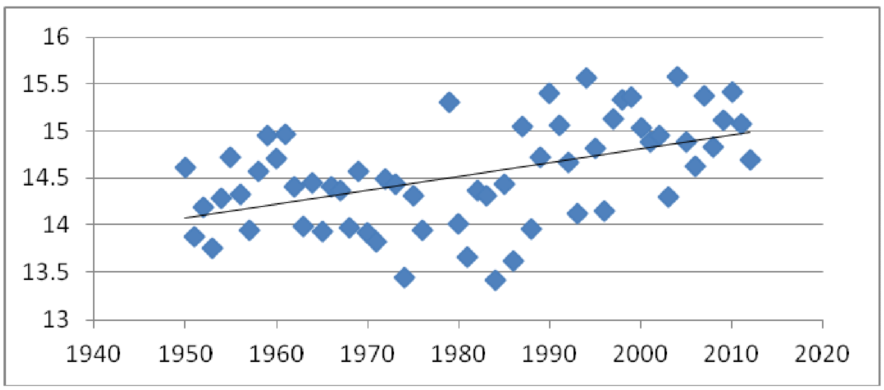
HO#8K Fairbanks International Airport y=0.0224x-46.9401 r^2=.14



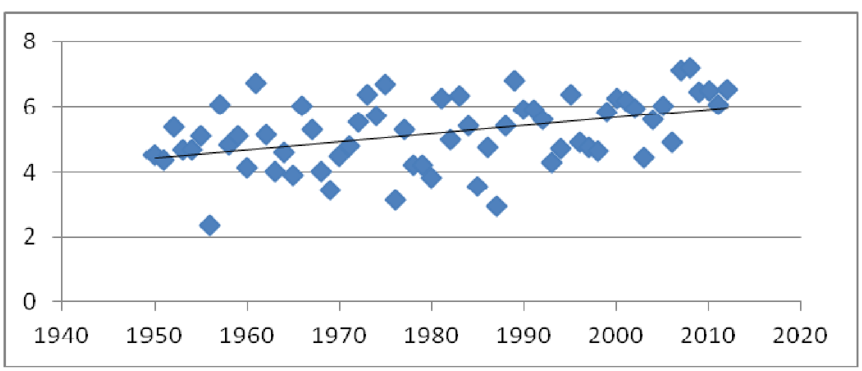
HO#8L Tacloban, Philippines   y=0.0160x-4.7013 r^2=.63



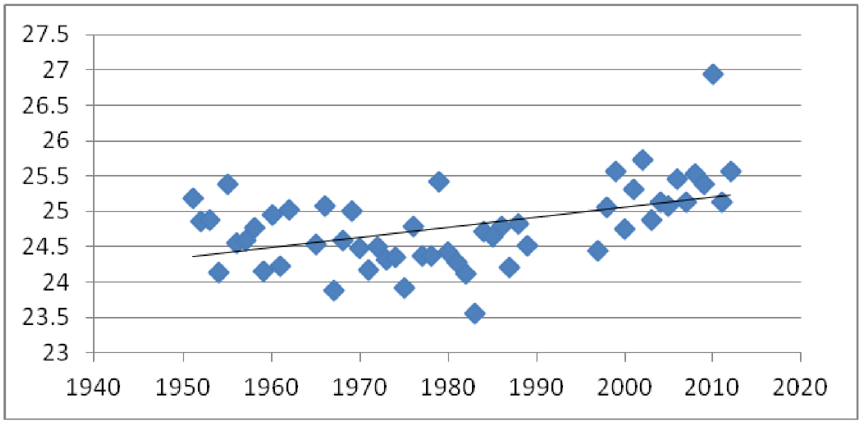
HO#8M Maebashi, Japan   y=0.0148x-14.7280 r^2=.25



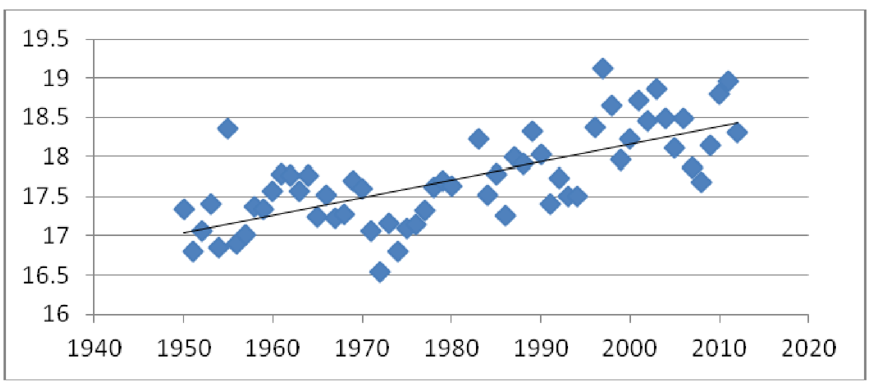
HO#8N Moscow, Russia   y=0.0264x-43.5833 r^2=.18



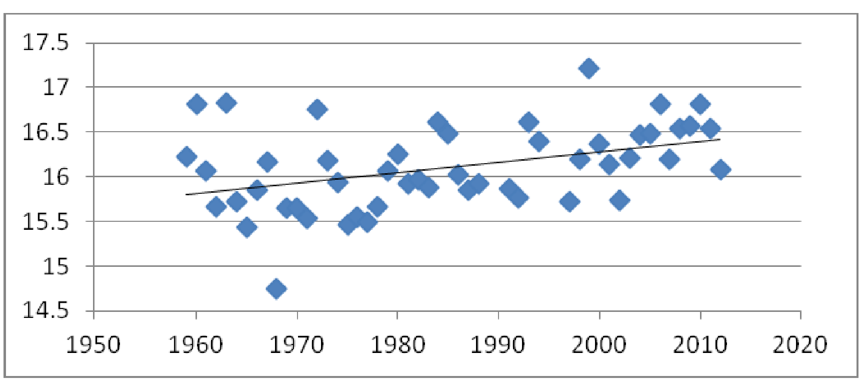
HO#8O Kharga, Egypt y=0.0144x-3.8279 r^2=.22



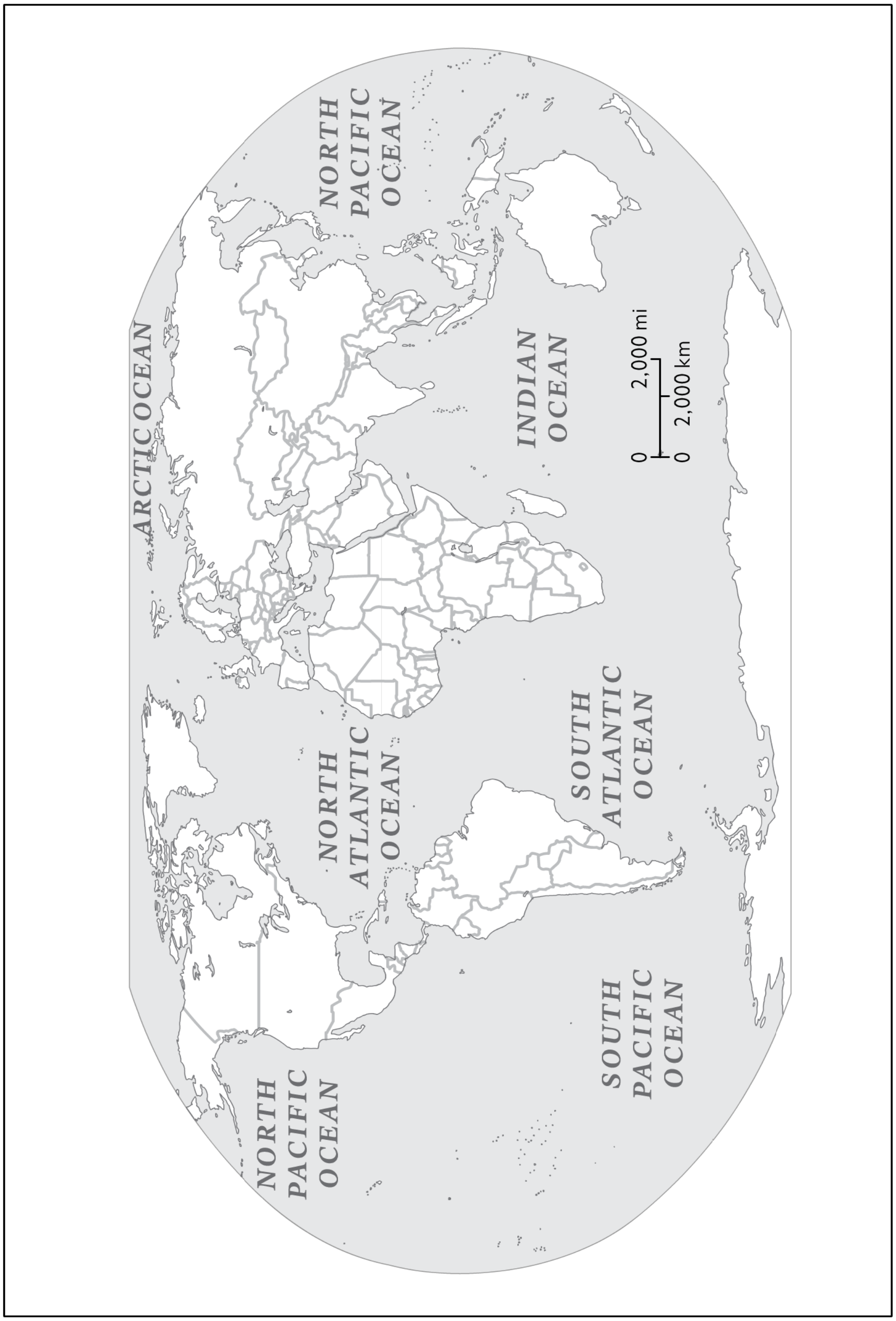
HO#8P Casablanca, Morocco (Western Africa) y=0.0224x-26.7070 r^2=.49



HO 8Q Calvinia, South Africa y=0.0118x-7.4039 r^2=.17



Map courtesy National Geographic Education. National Geographic does not review or endorse content added to this background by others.



THE WORLD

NATIONAL GEOGRAPHIC education

Name____ Date_______ HO#8S

Trends in Temperature Scoring Guide

Student Name___________________________________

Task	5 Student completed task correctly.	3 Student attempted task but did not complete it accurately.	0 Student did not attempt task.
Made scatterplot.			
Found equation of model.			
Explained the meaning coefficients and constants in the equation for the model.			
Used model to extrapolate temperatures for indicated years.			
Student explained how far into the future the model would be reasonable.			
Explained information to the class.			

Teacher comments:

Total grade: _____ out of 30

Student Exploration 5:

Students will explore key indicators of climate change.

Mathematical Objective(s):

- The student will plot data in a scatter plot.
- The student will create a model to represent the data.
- The student will interpret data.
- The student will use the model to extrapolate.

Additional Objectives for Student Learning:

- The students will explore key indicators of climate change.

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Materials and Resources:

- Computers with internet access
- Access to spread sheet software or graphing calculators
- Presentation materials
- Attached handouts

Student/Teacher Actions:

- The teacher should familiarize students with concept of a climate change indicator. The following resources may be used to explain the term and to engage students:
  A slide show from the EPA:
  http://www.epa.gov/climatechange/science/indicators/
  NASA page with demonstrations and visual data
  http://climate.nasa.gov/key_indicators/
  NASA Earth Science Video
  https://www.youtube.com/watch?v=hqk7ugr9jXQ&playnext=1&list=PL9637F677064E8453&feature=results_main

- Data is given for five key indicators in handouts 9A through 9E. Assign students to groups as appropriate for your class.

- Students will create a scatter plot and trend line for their given location. The teacher may elect to do this on graph paper, in a graphing calculator or in Excel.

- The students will create a visual model of their data to share with the class.

- The students will use their model to extrapolate.

- The students will present their information to the class.

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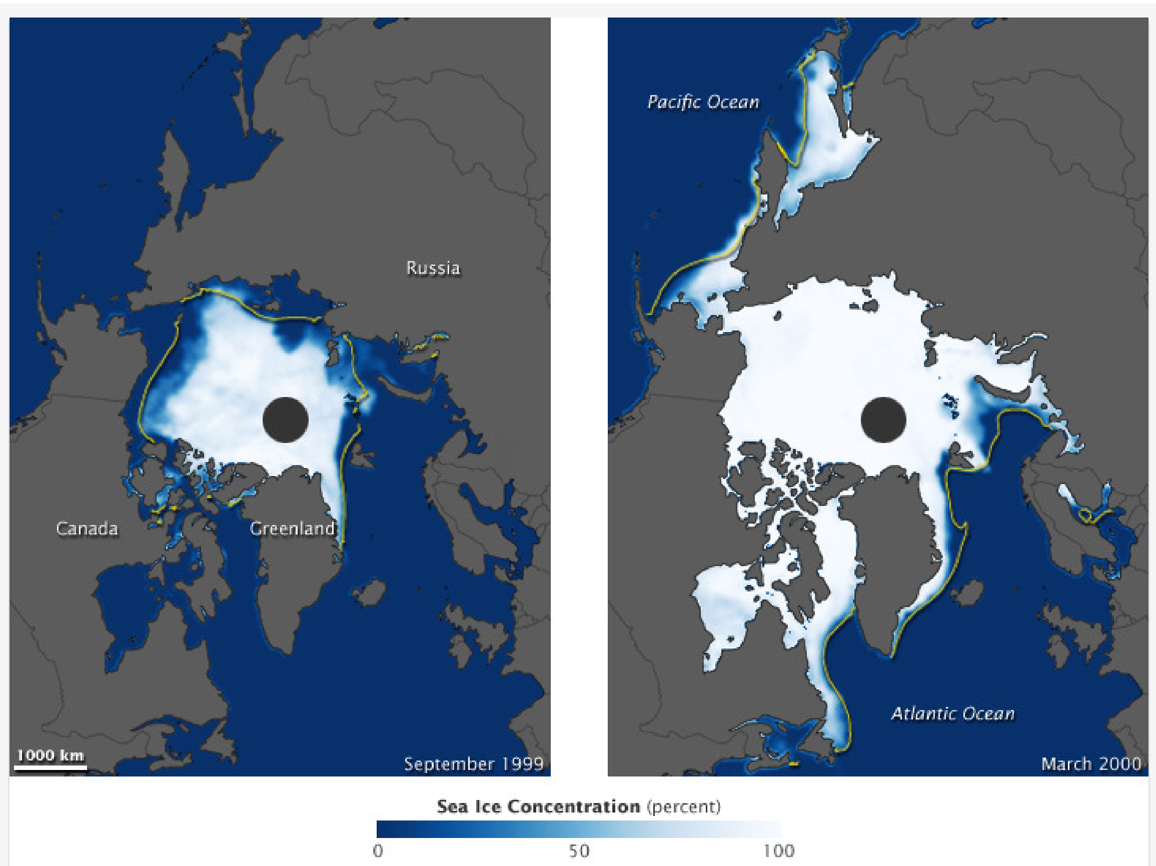
- The teacher will lead a discussion about what these indicators mean for the future of the planet, and specifically, any impact on students' lives.

- Extensions:
    - Encourage students to use the web site to explore additional indicators
    - Encourage students to research news stories about specific indicators
    - Encourage students to research the causes of climate change

Name____ Date_______ HO#9A

Indicator of Climate Change: Sea Ice

The Sea Ice Index values represent ice cover in millions of square kilometers in the Arctic and Antarctic oceans. This data represents ice cover in the month of September. Although data for every month is available, September was chosen because it is typically when the sea ice cover reaches its annual minimum after melting during the spring and summer. Data for this indicator were gathered by the National Snow and Ice Data Center using satellite imaging technology.



http://earthobservatory.nasa.gov/Features/WorldOfChange/sea_ice.php

Complete the following tasks using the data on the back of this page.

- Make a scatterplot of the data.
- Determine the equation of a model that fits the data and draw it on the scatterplot.
- Explain the meaning of the coefficients and constants in your equation.
- What does this data tell you?
- What questions does this data raise in your mind?
- Use your model to extrapolate the Sea Ice Area in the year 2050.
- Be prepared to explain the above information to the class.

Year	Sea Ice Area (mil. of km^2)
1979	4.53
1980	4.83
1981	4.38
1982	4.38
1983	4.63
1984	4.05
1985	4.17
1986	4.66
1987	5.6
1988	5.31
1989	4.81
1990	4.5
1991	4.46
1992	5.37
1993	4.52
1994	5.08
1995	4.38

Year	Sea Ice Area (mil. of km^2)
1996	5.58
1997	4.84
1998	4.24
1999	4.22
2000	4.31
2001	4.55
2002	3.98
2003	4.01
2004	4.35
2005	4.03
2006	3.97
2007	2.78
2008	2.99
2009	3.47
2010	3.07
2011	2.94
2012	2.11

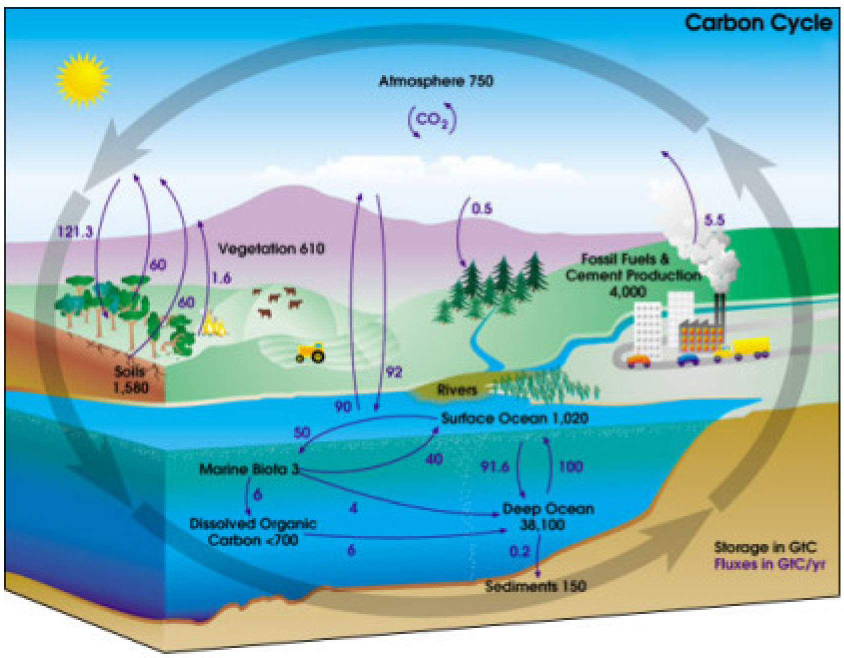
retrieved from http://nsidc.org/data/seaice_index/

Name____ Date_______ HO#9B

Indicator of Climate Change: CO_2 levels

The following data represent the concentrations of CO_2 in the Earth's atmosphere in parts per million derived from air measurements at the Mauna Loa Observatory, Hawaii.

Carbon dioxide (CO_2) is the primary greenhouse gas emitted through human activities. Carbon dioxide is naturally present in the atmosphere as part of the Earth's carbon cycle, but human-related emissions are responsible for the increase that has occurred in the atmosphere since the industrial revolution. (http://www.epa.gov/climatechange/ghgemissions/gases/co2.html)



http://earthobservatory.nasa.gov/Features/CarbonCycle/carbon_cycle2001.pdf

Complete the following tasks using the data on the back of this page.

- Make a scatterplot of the data.
- Determine the equation of a model that fits the data and draw it on the scatterplot.
- Explain the meaning of the coefficients and constants in your equation.
- What does this data tell you?
- What questions does this data raise in your mind?
- Use your model to extrapolate the CO_2 level in the year 2050.
- Be prepared to explain the above information to the class.

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Year	CO_2 level (ppm)
1959	315.97
1960	316.91
1961	317.64
1962	318.45
1963	318.99
1964	319.62
1965	320.04
1966	321.38
1967	322.16
1968	323.04
1969	324.62
1970	325.68
1971	326.32
1972	327.45
1973	329.68
1974	330.18
1975	331.08
1976	332.05

Year	CO_2 level (ppm)
1977	333.78
1978	335.41
1979	336.78
1980	338.68
1981	340.1
1982	341.44
1983	343.03
1984	344.58
1985	346.04
1986	347.39
1987	349.16
1988	351.56
1989	353.07
1990	354.35
1991	355.57
1992	356.38
1993	357.07
1994	358.82

Year	CO_2 level (ppm)
1995	360.8
1996	362.59
1997	363.71
1998	366.65
1999	368.33
2000	369.52
2001	371.13
2002	373.22
2003	375.77
2004	377.49
2005	379.8
2006	381.9
2007	383.76
2008	385.59
2009	387.37
2010	389.85
2011	391.63
2012	393.81

Retrieved from: ftp://ftp.cmdl.noaa.gov/ccg/co2/trends/co2_annmean_mlo.txt

Name____ Date_______ HO#9C

Indicator of Climate Change: Global Mean Sea Level

The following data represent the global mean sea level in millimeters. Mean sea level (MSL) is a measure of the average height of the ocean's surface, basically the halfway point between the mean high tide and the mean low tide.

Hatteras Island, NC 10/31/12 Photos courtesy of Kat Egeland

Complete the following tasks using the data on the back of this page.

- Make a scatterplot of the data.
- Determine the equation of a model that fits the data and draw it on the scatterplot.
- Explain the meaning of the coefficients and constants in your equation.
- What does this data tell you?
- What questions does this data raise in your mind?
- Use your model to extrapolate the Global Mean Sea Level in the year 2050.
- Be prepared to explain the above information to the class.

Year	GMSL (mm)
1950	-65.7
1951	-56.2
1952	-58.8
1953	-54.4
1954	-57.3
1955	-56.4
1956	-61.5
1957	-48.1
1958	-46.7
1959	-46.4
1960	-42.7
1961	-36.5
1962	-41.7
1963	-43.3
1964	-51.2
1965	-40
1966	-45.4
1967	-44
1968	-43.2
1969	-36.4

Year	GMSL (mm)
1970	-38.3
1971	-33.1
1972	-24
1973	-30
1974	-18.1
1975	-19.7
1976	-20.7
1977	-22.4
1978	-16
1979	-20.9
1980	-14.9
1981	-2.5
1982	-8.3
1983	0.1
1984	-0.8
1985	-11.1
1986	-10.5
1987	-9.9
1988	-5.2
1989	-0.7

Year	GMSL (mm)
1990	0.7
1991	3.8
1992	6.6
1993	2.1
1994	5.5
1995	10.7
1996	14.4
1997	22.6
1998	15
1999	21.7
2000	22.6
2001	27.1
2002	26.1
2003	35.1
2004	34.5
2005	34.1
2006	35.6
2007	39.1
2008	49
2009	55.5

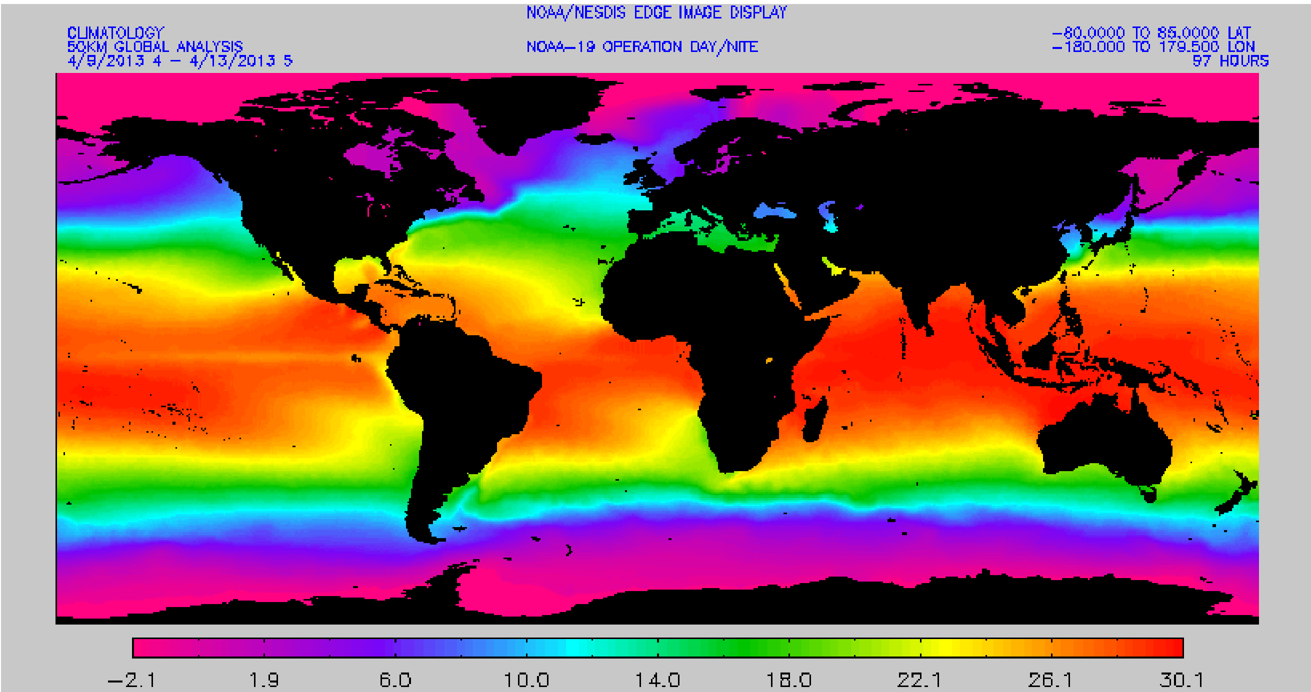
Retrieved from: http://www.cmar.csiro.au/sealevel/sl_data_cmar.html

Name____ Date_______ HO#9D

Indicator of Climate Change: Ocean Temperature

When sunlight reaches the Earth's surface, the world's oceans absorb some of this energy and store it as heat. This heat is initially absorbed at the surface, but some of it eventually spreads to deeper waters.

This data indicates the global ocean heat content for the top 700 meters of the ocean, which is about 20% of the volume in the world's oceans. It is measured in joules X 10^{22}, which is a unit of energy.



http://www.osdpd.noaa.gov/data/sst/fields/FS_km5001.gif

Complete the following tasks using the data on the back of this page.

- Make a scatterplot of the data.
- Determine the equation of a model that fits the data and draw it on the scatterplot.
- Explain the meaning of the coefficients and constants in your equation.
- What does this data tell you?
- What questions does this data raise in your mind?
- Use your model to extrapolate the Ocean Temperature in the year 2050.
- Be prepared to explain the above information to the class.

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Year	Joules 1E22
1950	-8.75
1951	-5.99
1952	-5.37
1953	-5.31
1954	-3.61
1955	-1.15
1956	-0.75
1957	3.33
1958	3.36
1959	3.64
1960	0.09
1961	0.84
1962	1.16
1963	0.97
1964	-0.11
1965	0.73
1966	1.92
1967	1.3
1968	-1
1969	-2.2

Year	Joules 1E22
1970	-0.7
1971	0.37
1972	0.82
1973	0.13
1974	-0.01
1975	-0.99
1976	-0.16
1977	-0.49
1978	0.9
1979	2.59
1980	4.31
1981	5.32
1982	4.65
1983	4.66
1984	4.2
1985	4.49
1986	5.11
1987	6.88
1988	7.95
1989	9.04

Year	Joules 1E22
1990	-0.7
1991	0.37
1992	0.82
1993	0.13
1994	-0.01
1995	-0.99
1996	-0.16
1997	-0.49
1998	0.9
1999	2.59
2000	4.31
2001	5.32
2002	4.65
2003	4.66
2004	4.2
2005	4.49
2006	5.11
2007	6.88
2008	7.95
2009	9.04

retrieved from http://www.cmar.csiro.au/sealevel/sl_data_cmar.html

Name____ Date_______ HO#9E

Indicator of Climate Change: Glacier Mass

The Glacier Mass Balance is measured by determining the amount of snow accumulated during winter, and that is remaining at the end of the melt season, and measuring the amount of snow and ice removed by melting in the summer. The difference between these two parameters is the mass balance. If the amount of snow accumulated during the winter is larger than the amount of melted snow and ice during the summer, the mass balance is positive and the glacier has increased in volume. On the other hand, if the melting of snow and ice during the summer is larger than the supply of snow in the winter, the mass balance is negative and the glacier volume decreases. Mass balance is reported in meters of water equivalent.

This data indicates the mass balance for the South Cascade Glacier in Alaska.

http://ak.water.usgs.gov/glaciology/south_cascade/photos/2000%20USGS%20photo%20sharpened.jpg

Complete the following tasks using this data:

- Make a scatterplot of the data.
- Determine the equation of a model that fits the data and draw it on the scatterplot.
- Explain the meaning of the coefficients and constants in your equation.
- What does this data tell you?
- What questions does this data raise in your mind?
- Use your model to extrapolate the mass balance for the South Cascade Glacier in the year 2050.
- Be prepared to explain the above information to the class.

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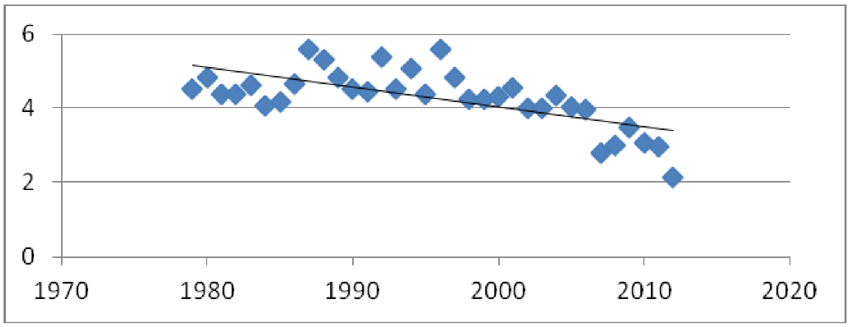
Year	Mass Balance (m^3 of water)		Year	Mass Balance (m^3 of water)		Year	Mass Balance (m^3 of water)		Year	Mass Balance (m^3 of water)
1959	0.7		1971	0.6		1983	-0.77		1995	-0.69
1960	-0.5		1972	1.43		1984	0.12		1996	0.1
1961	-1.1		1973	-1.04		1985	-1.2		1997	0.63
1962	0.2		1974	1.02		1986	-0.61		1998	-1.86
1963	-1.3		1975	-0.05		1987	-2.06		1999	1.02
1964	1.2		1976	0.95		1988	-1.34		2000	0.38
1965	-0.17		1977	-1.3		1989	-0.91		2001	-1.57
1966	-1.03		1978	-0.38		1990	-0.11		2002	0.55
1967	-0.63		1979	-1.56		1991	0.07		2003	-2.1
1968	0.01		1980	-1.02		1992	-2.01		2004	-1.65
1969	-0.73		1981	-0.84		1993	-1.23		2005	-2.45
1970	-1.2		1982	0.08		1994	-1.6		2006	---

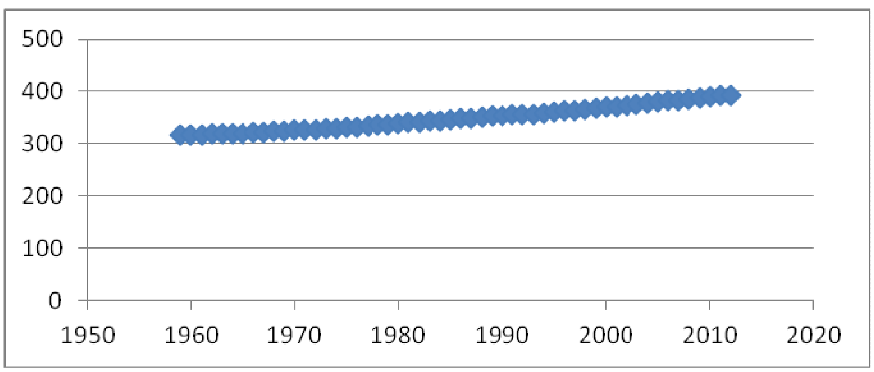
Retrieved from: http://ak.water.usgs.gov/glaciology/all_bmg/3glacier_balance.htm

Answer Keys to Indicators Handouts HO#9_

***HO#9A Indicator of Climate Change*: Sea Ice** $y=-0.533x + 110.5825$ $r^2 = .45$



***HO#9B Indicator of Climate Change*: CO2 Levels** $y=1.4830x-2595.5438$ $r^2 = .99$



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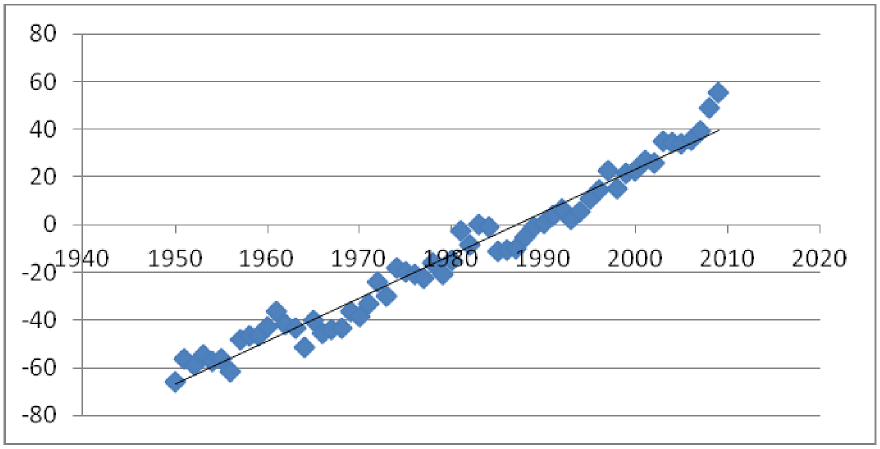
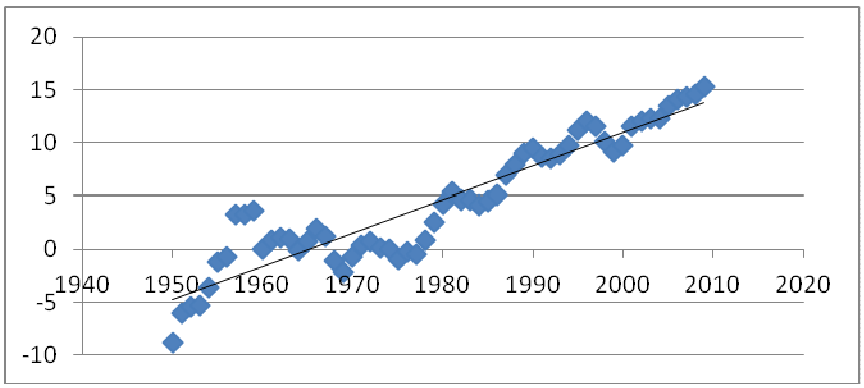
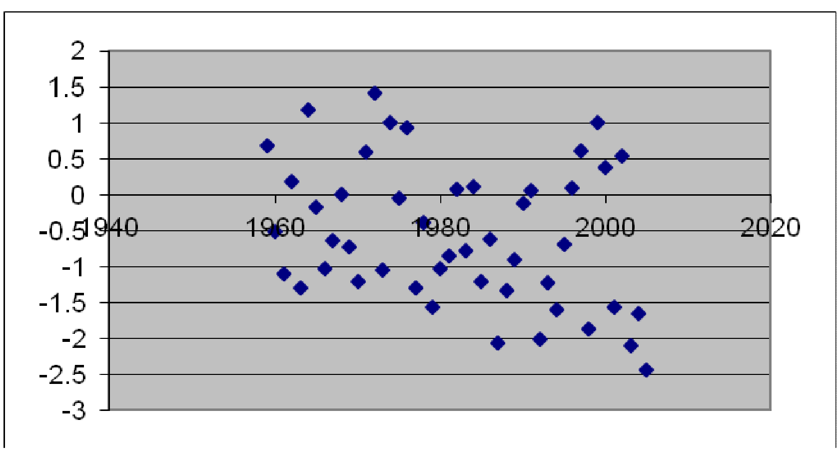
***HO#9C Indicator of Climate Change*: Global Mean Sea Level** y=0.5375x+1986.8550 r^2=.97



***HO#9D Indicator of Climate Change*: Ocean Temperature** y=2.7394x +1967.1349 r^2=.86



***HO#9E Indicator of Climate Change*: Glacier Mass** y=-4.1175x+1979.7269 r^2=.09



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Name____ Date_______ HO#9F

Key Indicators Scoring Guide

Task	5 Student completed task correctly.	3 Student attempted task but did not complete it accurately.	0 Student did not attempt task.
Made scatterplot.			
Found equation of model.			
Explained the meaning coefficients and constants in the equation for the model.			
Explained what the data told him/her.			
Generated questions based on the data.			
Used model to extrapolate temperature in the year 2050.			
Explained information to the class.			

Teacher comments:

Total grade: _____ out of 35

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Final Project: Rolling with the changes

After exploring trends in climate change and the ways in which rising temperatures are altering the environment, students will explore possible solutions or accommodations to help them in their own lives in a future which may well include more rising temperatures. The following websites are suggested as resources for suggestions for working to offset or adapt to climate change. In addition to these, students may conduct their own research.

http://climate.nasa.gov/solutions

http://www.environment.ucla.edu/cccs/

http://www.scientificamerican.com/article.cfm?id=10-solutions-for-climate-change

http://www.epa.gov/climatechange/impacts-adaptation/

https://www.gov.uk/government/policies/adapting-to-climate-change

Allow students time to discuss what they have learned, and think about possible concerns that they have for their future. As necessary the teacher may prompt students to think about such topics as: conditions for growing crops, changing wild life habitats, loss of shore line and flooding of cities, heating and cooling costs, severe weather damages or changes to recreational areas like ski resorts and beaches.

Working in pairs, students will select an area of concern and plan an action to offset or adapt to climate change. They will then create mathematical models to predict the rate at which climate change will affect the area of concern, and the degree to which their plan of action will offset or allow them to adapt to change. The mathematics involved would be systems of equations or perhaps simple linear programming models or bivariate data analysis. The final product will have students argue for or against the action that they have explored.

Examples of comparisons:

- Rate of CO_2 increase and projected increases in CO_2 levels compared with the potential CO_2 consumption of controlled algae blooms or artificial trees.
- Rate of temperature increase in farmlands in various regions and a plan to move crops to new regions to keep abreast of changes while keeping food supplies stable.
- Based on temperature change, when would it be appropriate to consider moving wildlife to suitable new habitats?

* After the pairs project has been completed, the teacher may choose to use the original survey on attitudes about the power of mathematics. You may wish to compare students' responses after the project to their responses at the beginning of the unit.

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Name____ Date__________ HO#10

Climate Change Pairs Project: Rolling with the Changes

Working in pairs, you will select a topic of concern to you regarding climate change. Will increasing temperatures change the way that you may need to heat or cool your home as you grow older? Will changes in the environment affect your food supply? Are you concerned with how habitats for wild life will change? Will your favorite beach or mountain resort be damaged? Choose an area of concern and make predictions about how rapidly climate change will affect this aspect of your life. Have your teacher approve your ideas before moving forward.

What is your area of concern?

Now that you and your partner have agreed on an area of concern, what will you do to address your own concerns? Will you try to find a way to keep the change from happening, or find a way to adapt to the changes? Many people in the world are thinking about these things. Do some research, and decide on one action that you might take to either off-set or adapt to climate change. Have your teacher approve the action that you are going to research.

What action will you research?

Your final task in this unit is to compare your area of concern to the action that you are considering. You will need a model to predict the impact of climate change over your life time. In addition, you will need a mathematical model to predict the effectiveness or the appropriate timing for your action. You may use any mathematical technique that you consider appropriate for this. Compare your models and decide if your action to off-set change or adapt to it will be appropriate for you.

Write a report about your conclusions. Your report should include a description of your area of concern, and a description of your chosen action. Include all of your prediction models, including all raw data that you used to make the model. Include any charts, graphs or equations that you used in your analysis. At the end of your paper, explain your thoughts about your chosen action. Will this action help improve your situation, or help others? Is it a reasonable action to take? Will you consider taking this action as you get older?

Name____ Date___________ HO#11

Rolling with the Changes

	0/1	2/3	4	5	Teacher Score
Appropriate topic of concern was selected and described.	Not included	Meets some criteria	Meets most criteria	Meets all criteria	
Comments:					
Appropriate adaptation or action was selected and described.	Not included	Meets some criteria	Meets most criteria	Meets all criteria	
Comments:					
Topic of concern was modeled mathematically using valid data.	Not included	Meets some criteria	Meets most criteria	Meets all criteria	
Comments:					
Adaptation or action was modeled using valid data.	Not included	Meets some criteria	Meets most criteria	Meets all criteria	
Comments:					
An analytical comparison of the models was presented.	Not included	Meets some criteria	Meets most criteria	Meets all criteria	
Comments:					
Conclusion is logically valid based on the mathematics.	Not included	Meets some criteria	Meets most criteria	Meets all criteria	
Comments:					
All appropriate tables, charts, graphs and calculations were included to support conclusions.	Not included	Meets some criteria	Meets most criteria	Meets all criteria	
Comments:					

Overall comments:

Total grade: _____ out of 35

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Name____ Date_______ HO#12

Please respond to the following questions by rating how strongly you agree with the following statements. 4 means strong agreement, 0 means strong disagreement. 2 means no opinion or belief.

	0 strongly disagree	1 disagree	2 no opinion	3 agree	4 strongly agree
I believe that mathematics can help people understand the world around them.					
I believe that professional mathematicians can use mathematics to help me understand the world.					
I believe that I can do mathematics for myself that will help me understand the world.					
I believe that I can do mathematics that will help others around me to understand the world.					
I believe that I can use mathematics to help make positive changes in the world.					

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