**Subject area/course**: Science

**Grade level/band**: 6-7

**Task source**: Achieve

**Four Cities**

**STUDENT INSTRUCTIONS**

1. **Task context**:

You have friends who live in different cities around the United States: (1) Seattle, Washington; (2) San Francisco, California; (3) Minneapolis, Minnesota; (4) and Las Vegas, Nevada. When you talk with your friends, you often wonder why the climate patterns seem so different across the country at given times of the year. For example, your friend in Minneapolis talks about getting time off from school for snow days in the winter, while your friend in Las Vegas tells you how high the temperatures reach in the summer. Your friend in Seattle tells you that it is often rainy, although the temperatures never seem to get too extreme. Your friend in San Francisco tells you about the fog that can blanket the city in spring and summer. In this task, you will look at climate data taken from each of these cities to determine what causes the climate variations you and your friends experience in your respective locations.

1. **Final product**:

For this task, you are going to consider what climate means for your school’s location (town), consider the climates of the cities in which your friends live, consider reasons for the differences in climate between the cities, and then make a model that predicts the types of regional climates in the western half of the United States.

**Task Components**

A. Consider and compare the daily temperature data from your school’s location for the same month from two different years (e.g., October, 2013, and October, 2014). Create one scatterplot for each year (two scatterplots total). For each scatterplot, do the following:

* Use the daily temperature data in the chart your teacher has provided you [see example in Attachment 1] to determine the range, mean, and median values for the high temperatures and the range, mean, and median values for the low temperatures in the month.
* Plot the daily temperatures for the month on a scatterplot [Attachment 3], with one line showing the daily high temperatures and a second line showing the daily low temperatures. The points on the scatterplot can be connected so that the changes within each dataset for the month are clearly shown.
* Draw a horizontal line on the scatterplot to represent the mean high temperature you calculated, and then draw another horizontal line on the scatterplot to represent the mean low temperature you calculated.

1. Use the scatterplots of the high and low temperatures for each year that you have made to create an evidenced-based description of what the measures of center (mean, median, and mode) can tell you about the expected temperatures for that month. How is the range evident on the graphs? If the variance in the data affects the measures of center, address this in your explanation.
2. Using both of the scatterplots you have created, write a description that compares the two populations of temperature data (the same month in two different years), noting areas of overlap and any similarities or differences in the pattern of the data on the scatterplot, the measures of center, and the range.

B. Use the data of the average monthly high and low temperatures of your school’s location provided by your teacher (see Attachment 2) to make a new scatterplot showing the changes in average monthly high and low temperatures over the course of the year (Attachment 4). Monthly climatological data is created from the mean high and low temperatures for the same month (e.g., October) in many different years. Compare this scatterplot with the two daily temperature scatterplots you made previously. From your observations, create an evidence-based argument for why, when climate scientists want to study the differences in climate between two areas, they rely on the mean (average) monthly data calculated from many different years rather than the mean daily temperature data from one entire year.

C. For the cities of Seattle, San Francisco, Las Vegas, and Minneapolis, use the provided temperature data (Attachment 6) to make two graphs per city:

* One graph showing scatterplots for two different data sets: one set of data for the average monthly high temperature and a second set of data for the average monthly low temperature. The points on the scatterplot should be connected so that the changes within each dataset for the month are clearly shown;
* A bar graph showing the average precipitation per month for a year (Attachment 5).

D. Compare the temperature scatterplots for Minneapolis, MN, and Las Vegas, NV. Consider the difference between the cities in the average monthly high temperature during the hottest month and the difference between the cities in average monthly high temperature during the coldest month. Construct an argument to evaluate the claim that temperature differences observed in the scatterplots can be accounted for by differences in latitude (Attachment 7). Account for the differences between cities in terms of the heating from solar energy or the transfer of thermal energy in your argument.

On a map of the western half of the United States (Attachment 11), identify regions where differences in latitude affect the climate by:

* Labeling areas of the map where the climate would be affected (in terms of where differences in temperature occur, based on latitude);
* Indicating on the map the possible cause of the differences in climate (in terms of heating from solar energy and/or the transfer of thermal energy).

E. Seattle, WA (47.6097° N) is located at a more northern latitude than is Minneapolis, MN (44.9833° N). Compare the temperature scatterplots for these two cities. Consider the difference in the yearly range in temperatures between the two cities and the difference in the temperatures of the hottest and coldest months for each city. Construct an explanation for how the differences between the cities’ temperature ranges and max/min temperatures can be accounted for by the geographic location of Seattle relative to the geographic location of Minneapolis (Attachment 7). Account for the differences between these cities in terms of the heating from solar energy or the transfer of thermal energy in your explanation.

On the map of the western half of the United States (Attachment 11), use your explanation about the differences between Seattle and Minneapolis to identify regions where the proximity to certain geographic features will affect the climate by:

* Labeling areas on the map where differences in temperature occur, based on proximity to geographic features;
* Indicating on the map the possible cause of the differences in climate (in terms of heating from solar energy and/or the transfer of thermal energy);
* Drawing arrows with labels showing the direction of energy movement if there is a transfer of thermal energy.

F. Seattle, WA (47.6097° N) is located at a significantly higher latitude than is San Francisco, CA (37.7833° N), but it has a similar geographic location: on the West Coast of North America. Compare the temperature scatterplots for these two cities. Consider the difference between the cities with regard to the yearly range in temperatures and the difference in the temperatures for the hottest and coldest months for each city. The California ocean current runs along the coast of California, bringing cold water from the north to the south and from deeper in the ocean up to the surface (Attachment 8). Construct an explanation for how ocean currents, driven by temperature differences and the Coriolis effect, can have a causal role in determining the differences between the cities’ temperature ranges and max/min temperatures when both cities are located on the same coast. Account for the differences between cities in terms of the heating from solar energy or the transfer of thermal energy in your explanation.

On the map of the western half of the US, identify regions where ocean currents will affect the climate by:

* Labeling areas on the map where differences in temperature occur, based on ocean currents;
* Indicating on the map the possible cause of the differences in climate (in terms of heating from solar energy and/or the transfer of thermal energy);
* Drawing arrows with labels showing the direction of ocean water circulation that would lead to differences in temperature;
* Drawing arrows with labels showing the direction of energy movement if there is a transfer of thermal energy.

G. Consider the maps showing the topography around Seattle, San Francisco, and Las Vegas (Attachment 10). Winter precipitation data for Minneapolis represent the amount of precipitation from snowfall because it is cold enough in the winter for all the precipitation to be frozen as snow and ice. Although it would be unusual to have snow in the cities of Seattle, San Francisco, and Las Vegas, it does snow in the mountains near these cities. Construct an explanation that addresses why snowfall occurs in certain areas near these cities, even though it is usually too warm in the cities, themselves, for snow to fall there.

On the map of the western US (Attachment 11), use your explanation to identify regions where topography and altitude will affect the climate by:

* Labeling areas on the map where differences in temperature are likely to occur, based on topography.

H. Las Vegas (36.0800° N) and San Francisco, CA (37.7833° N) are located at similar latitudes. Compare the precipitation data for these cities. Use the map of wind direction (the Westerlies, Attachment 9) and the topography of the land between the two cities (Attachment 10) to construct an explanation for what causes the difference in precipitation data between the two cities.

On the map of the western US, use your explanation to identify regions where the prevailing wind direction (and topography) will affect the climate by:

* Labeling areas on the map where differences in precipitation occur;
* Drawing arrows with labels showing the direction of air movement that would lead to differences in precipitation.

I. Use your labeled map as a model for the western United States climate system, describe specifically where and how air and ocean circulation patterns are affecting climate in this system. Then, develop an argument from evidence that similar patterns occur throughout the Earth, and therefore that unequal heating and the rotation of the Earth creates the patterns of air circulation on the planet.

**Additional Information**

1. **Knowledge and skills you will need to demonstrate on this task:**

* **Task Components A and B** ask students to plot and interpret daily and monthly average temperature values for their school’s location (town), and **Task Component** **C** asks students to plot average temperature and precipitation data for four selected cities.
* **Task Components C, D, E, F, G, and H** ask students to compare the temperature and precipitation data of four selected cities to evaluate how latitude, geographic location, ocean currents, prevailing wind direction, altitude, and topography influence the regional climates of these cities and to build a map outlining where these will affect climate in the western half of the United States.
* **Task Component I** asks students to describe how unequal heating and the rotation of the Earth causes air and ocean circulation patterns, and to use their labeled map as a model to describe how these patterns affect climate in the western half of the United States.

1. **Materials needed:**

* Graph paper (or charts provided in Attachments 3, 4, and 5 in Instructional Materials)
* The teacher may decide to use a spreadsheet application for creating the scatterplots or to use a program such as GoogleEarthTM to show topography. If so, students will need to have access to these programs and know how to use them.

1. **Time requirements:**

The entire task will take from 4 to 8 class periods. However, your teacher will provide you with more information about the timing of each task component.

1. **Scoring:**

Your work will be scored using the SCALE Scientific Practices rubric. You should make sure you are familiar with the language that describes the expectations for proficient performance.