**Subject area/course**: Science

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

**Task source**: Achieve

**Four Cities**

**TEACHER'S GUIDE**

1. **Task overview**:

In this task, students will demonstrate their ability to describe and interpret plotted climate data to explain the reasons for differences in climate among four different United States cities: Seattle, Washington; San Francisco, California; Minneapolis, Minnesota; and Las Vegas, Nevada. The cities were chosen to show the effect latitude, topography, ocean circulation patterns, and wind circulation patterns have on the mean monthly high and low temperatures and the average monthly precipitation. The task consists of two parts. First, students compare daily temperature data with mean monthly temperature data from the town in which their school is located, which will demonstrate their understanding of climate data within their own region. Second, students compare climate data among the cities listed above, examining the effects of latitude, topography, ocean circulation patterns, and wind circulation patterns on the mean monthly high and low temperatures and the average monthly precipitation.

1. **Aligned standards:**
2. **Primary Common Core State Standards**

**CCSS.6.SP.A.2** Understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape.

**CCSS.6.SP.A.3** Recognize that a measure of center for a numerical data set summarizes all of its values with a single number, while a measure of variation describes how its values vary with a single number.

**CCSS.6.SP.B.4** Display numerical data in plots on a number line, including dot plots, histograms, and box plots.

**CCSS.6.SP.B.5c** Summarize numerical data sets in relation to their context, by:
Giving quantitative measures of center (median and/or mean) and variability (interquartile range and/or mean absolute deviation), as well as describing any overall pattern and any striking deviations from the overall pattern with reference to the context in which the data were gathered.

**CCSS.7.SP.B.4** Use measures of center and measures of variability for numerical data from random samples to draw informal comparative inferences about two populations.

1. **Secondary Common Core State Standards (optional)**

**CCSS.W.7.2** Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

**CCSS.WHST.6-8.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

**CCSS.WHST.6-8.2.a** Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.

**CCSS.WHST.6-8.2.b** Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples.

1. **NGSS**

**Performance Expectations:**

**MS-ESS2-6.** Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.

**Disciplinary Core Ideas:**

**Weather and Climate:** [Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents.](http://www.nap.edu/openbook.php?record_id=13165&page=184)

**The Roles of Water in Earth’s Surface Processes:** [Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns.](http://www.nap.edu/openbook.php?record_id=13165&page=186) [The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents.](http://www.nap.edu/openbook.php?record_id=13165&page=186)

**Crosscutting Concepts and Science Practice:**

**Systems and System Models and Developing and Using Models:** The students **produce a map (model)** of the western half of the United States that indicates areas labeled where temperature and precipitation are affected by solar heating, energy transfer, and air and ocean circulation patterns. And students **use that model** **map** when explaining how and why the climate (temperature and precipitation) is affected.

1. **Critical abilities**

**Research:** Conduct sustained research projects to answer a question (including a self-generated question) or solve a problem, narrow or broaden the inquiry when appropriate, and demonstrate understanding of the subject under investigation. Gather relevant information from multiple authoritative print and digital sources, use advanced searches effectively, and assess the strengths and limitations of each source in terms of the specific task, purpose, and audience.

**Analysis of Information:** Integrate and synthesize multiple sources of information (e.g., texts, experiments, simulations) presented in diverse formats and media (e.g., visually, quantitatively, orally) in order to address a question, make informed decisions, understand a process, phenomenon, or concept, and solve problems while evaluating the credibility and accuracy of each source and noting any discrepancies among the data.

**Use of Technology:** Present information, findings, and supporting evidence, making strategic use of digital media and visual displays to enhance understanding. Use technology, including the Internet, to research, produce, publish, and update individual or shared products in response to ongoing feedback, including new arguments or information.

1. **Time/schedule requirements:**

The entire task could take from 4 to 8 class periods (45-50 minutes each), spread out over the course of an instructional unit, with divisions as listed below:

* Task Components A and B: 2 class periods, or fewer if the scatterplots are provided by the instructor or if the evidence-based explanation in Task Component B is used as homework.
* Task Component C: 1 class period, or no time if the scatterplots are provided by the instructor
* Task Components D, E, F, G, and H: each up to 1 class period, depending on whether the explanations are used as homework
* Task Component I: 1-2 class periods, depending on whether the students have been labeling the map as they do the other task components.
1. **Materials/resources:**
* 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. **Prior knowledge:**
* Prior to each task component students should understand the scientific content behind the climate effect being assessed. For example, for Task Component G, it is assumed that students understand the rain shadow effect.
* It is assumed that students have a basic understanding of the geography of the United States, including where the four cities are located and what features they are located near (e.g., mountains, ocean, etc.).
1. **Connection to curriculum:**

This task is aimed at students in 6th or 7th grade, and was designed to align with the 7th grade NGSS Conceptual Progressions Model Course Map (NGSS, vol. 2, Appendix K). Task Components A and B are intended to be formative within an instructional unit covering weather and climate, in order to assess a student’s understanding of climate data prior to moving on to Task Components C through I. However, Task Component A could be used as a summative assessment within a mathematical unit on the statistical description of datasets, such as in a blended course model where the associated science unit would follow the math assessment.

Task Components C through I can be used as a series of assessments within an instructional unit on regional climate. Because the interpretation of the four cities’ scatterplots and bar graphs is essential for successful completion of the other task components, it is recommended that Task Component C serve as a formative assessment of math standards. Task Components D through H could each be used as formative assessments following lessons on each “climate affecting factor,” with Task Component I serving as a summative assessment on the whole unit. Task Components D through I could also be combined into one large summative assessment, provided that the students thoroughly understand all science content and principles addressed in the task components.

This task could be tailored to lower levels of the grade range by providing the scatterplots, rather than expecting students to construct them on their own. In addition, all components might be used as formative tasks rather than summative.

Although students are asked to create evidence-based explanations in this task, they are primarily describing and explaining data in the task components, so this task most closely aligns with the ELA/Literacy standards for writing to inform or to explain. Task Components A through G can be used as formative assessments, and Task Component I can be used for either formative or summative assessment.

1. **Teacher instructions:**

**Task Component A**

* Students represent daily temperature data on a scatterplot, and create one plot for each year.
* For each year, students calculate the range, mean, mode, and median values for high and low temperatures.
* Students use straight lines on the scatterplots to represent the calculated mean high and low temperature values.
1. Students use specific features from their scatterplots as evidence to describe each of the following:
	* The mean represents the temperature around which the data points are clustered, for the time period as represented by the data;
	* The mode represents the temperature that occurs most frequently in the data;
	* The median is the temperature that falls in the middle when the data values are listed in order from smallest to largest;
	* The range represents the difference between the smallest and largest data value (how much the data points are spread out);
	* Variance in the data indicates the differences between the data points and their mean. A high variance indicates that the data points are not equally distributed on either side of the mean line and may cause the mean to be higher or lower than the median.
2. Students compare the two data sets, describing:
* Similarities or differences in the mean, median, mode, and range values;
* Examples from the scatterplots of where the data ranges overlap;
* Similarities or differences in the pattern of data on the scatterplots.

**Task Component B**

* Students represent monthly average high and low temperatures on a scatterplot.
* Students make a claim that the mean (average) monthly data calculated from many years are more representative of the range of temperatures than an area could experience in any single month.
* Students descibe the following observations from daily and monthly data scatterplots as evidence, and connect the evidence to the claim with the following reasoning:
	+ The daily temperature data from a given year, including the mean and range, may be very different from the daily temperature data from a different year;
	+ The daily temperature data from a given year, including the mean and range, may be significantly higher or lower than other years;
	+ The mean of many years of climate data will take into account a much greater range in temperatures than is present from only one year of data;
	+ The range in data from many years is more likely to include or overlap with the range of data from any one year.

**Task Component C**

* Students represent the average monthly high and low temperatures on the scatterplots, creating one graph for each of the four cities.
* Students represent the average monthly precipitation on the bar graphs, creating one for each city.

**Task Component D**

* Students identify the given claim that higher latitudes have lower average temperatures, based on the differences in temepratures and differences in latitude between Minneapolis, MN and Las Vegas, NV.
* To evaluate the claim, students identify and describe the following patterns as evidence:
	+ That Las Vegas, NV, shows similar spread (magnitude of the range) of yearly temperature data as Minneapolis, MN, but that the range covers higher temperatures (from scatterplot);
	+ That Minneapolis, MN, is located at a higher latitude than Las Vegas, NV (from map).
	+ That lower latitudes receive more direct sunlight than do higher latitudes.
* Students evaluate the evidence for relevance and sufficiency to support the claim, including the distinction between correlation and causation, as it relates to their interpretation of the data from the graphs.
* Students synthesize the relevant evidence logically using the reasoning that the higher range of yearly temperature data correlates with lower latitudes, so the amount of direct sunlight might cause the higher temperature range found in Las Vegas (compared to Minneapolis)
* Students label the map of the western United States as follows:
	+ Adding labels in the higher latitudes indicating lower temperatures due to less solar heating;
	+ Adding labels in the lower latitudes indicating higher temperatures due to greater solar heating.

**Task Component E**

* Students construct an explanation that includes the idea that areas near the ocean do not experience as large of differences in average temperature from month to month as do areas far from the ocean, based on the differences in temperatures (range and minimum temperatures) between Minneapolis, MN and Seattle, WA.
* Students identify and describe the following patterns as evidence to construct the explanation:
	+ The yearly range in temperature is more narrow (i.e., not as great a difference in temperature from the cold to warm months) for data from Seattle, WA, than for the data from Minneapolis, MN (from the scatterplots);
	+ The average temperatures for the warmer months are similar in both cities, but that the average temperatures for colder months are lower in Minneapolis, MN, than in Seattle, WA (from the scatterplots);
	+ Minneapolis, MN, is geographically located in the interior of the continent and that Seattle, WA, is located by an ocean (from map).
	+ Both land and water absorb energy from the sun, but water (e.g., oceans) releases the energy more slowly than the land does.
* To construct the explanation, students connect the evidence logically using reasoning that the transfer of thermal energy from the ocean can account for the relationship between ocean proximity and range in average temperature.
* On the given map, students
	+ Identify and label areas of land near the ocean,
	+ Use arrows with labels to indicate the transfer of thermal energy between the land and the ocean.

**Task Component F**

* Students construct an explanation that includes the idea that the differences between the cities temperature ranges and max/min temperatures can be accounted for by the fact that ocean circulation places colder ocean water adjacent to San Francisco, CA relative to Seattle, WA.
* Students identify and describe the following patterns as evidence to construct their explanation:
	+ Both cities show a relatively narrow range in yearly temperature but that the range in data for San Francisco, CA, is narrower than the range of data from Seattle, WA (from scatterplot);
	+ Average temperatures for the warmer months in San Francisco, CA, are lower than the average temperatures for the warmer months in Seattle, WA (from scatterplot);
	+ Although both cities are located along the coast, San Francisco, CA, is located at a place where the ocean currents are bringing in colder ocean waters (from map).
* To construct the explanation, students connect the evidence logically using reasoning that ocean circulation for a given latitude moves ocean waters to places where they are colder/warmer than typical for that latitude, in a process caused by temperature differences and the Coriolis effect. The location and movement of these ocean currents can account for warmer/cooler than typical land temperatures.
* On the map of the western United States, students:
	+ Identify and label areas of land near the ocean, indicating a much smaller range of temperatures throughout the year due to the transfer of energy to and from colder-than-typical ocean currents;
	+ Add arrows showing the direction of ocean water circulation;
	+ Add arrows showing the transfer of thermal energy between the land and the ocean.

**Task Component G**

* Students construct an explanation that includes the idea that the colder temperatures at areas of higher altitude allow for snowfall to occur.
* Students identify and describe the following patterns as evidence to support their explanation:
* The relationship between type of precipitation (rain versus snow) and areas of great topographic relief.
* That some places on the map with snow are areas of higher altitude.
* The air pressure is lower at higher altitudes.
* Students use reasoning to logically connect the evidence to construct an explanation that colder temperatures, associated with lower pressure, at higher altitudes can account for the presence of snowfall in places with great topographic relief.
* Students label areas of higher elevation, indicating areas of colder temperatures due to a location at higher altitudes.

**Task Component H**

* Students construct an explanation that connects the difference in the amount of precipitation between San Francisco, CA, and Las Vegas, NV, with the direction of air movement from the west to east over an area of great topographic relief, and that includes the idea that areas to the west of the topographic highs get more precipitation than areas to the east of the topographic highs.
* Students identify and describe the following patterns as evidence in their explanation:
	+ The observation from the geographic map that there is an area of great topographic relief between San Francisco, CA, and Las Vegas, NV;
	+ The observation from the precipitation bar graphs that Las Vegas, NV, has much less average precipitation per year than San Francisco, CA;
	+ The observation from the image of prevailing wind directions that the wind patterns move air from over the ocean in the west to over the continent in the east;
	+ The observation from the image of prevailing wind directions and the geographic map that air moves from the area near San Francisco, CA, over an area of great topographic relief to the area near Las Vegas, NV.
* To construct their explanation, students connect the evidence logically using the reasoning that the connection between the amount of precipitation and the geographic location of the city can be accounted for by the loss of moisture in the air as it moves from west to east over the areas of great topographic relief (from the San Francisco, CA area to the area near Las Vegas, NV).
* On the map of the western United States, students:
	+ Identify and label areas of land to the east of mountain ranges as areas with less precipitation due to the movement of air over the mountain ranges;
	+ Identify and label areas of land to the west of mountain ranges as areas with more precipitation due to the movement of air over the mountain ranges;
	+ Add arrows showing the prevailing direction of air circulation (patterns of air movement).

**Task Component I**

* Students use their map as a model to identify where, and to describe how, air/ocean circulation affects climate in the western United States. Examples cited include:
	+ An example of where the movement of air affects the patterns of precipitation due to the rain shadow effect;
	+ An example of where the movement of ocean water affects average temperatures along the coast due to the ability of the ocean to buffer land temperatures.
* Students develop an argument that supports the claim that air/ocean circulation affects climate throughout the planet. In their argument, students identify the following patterns as evidence to support their claim:
	+ areas on the Earth where circulation of air due to unequal heating and the rotation of the Earth causes and defines the prevailing wind directions.
	+ areas on the Earth where circulation of water due to unequal heating causes and defines the ocean circulation patterns.
* Students evaluate the evidence for relevance and sufficiency for supporting the claim, including the idea that phenomena may have multiple contributing causes, and any limitations their evidence may pose (e.g., the use of models, correlation vs. causation).
* Students synthesize the relevant evidence, using the following reasoning:
* Unequal heating creates differences in density between warmer and colder air/water causing air/ocean circulation.
* The rotation of the Earth causes air and water circulation patterns to be deflected, such as to the right in the Northern Hemisphere (clockwise rotation) and to the left in the Southern Hemisphere (counter-clockwise rotation).
1. **Student support:**

Supplementary resources for diverse student groups' might be: writing applications for students who need scribes, translation materials, and discourse apps for students to converse (ask questions) of experts, including local climate specialists.

1. **Extensions or variations:**

When considering the effect of differences in latitude on climate, students might find the Seasons and Ecliptic Simulator to be a useful tool:

<http://astro.unl.edu/classaction/animations/coordsmotion/eclipticsimulator.html>

1. **Scoring:**

Student work can be scored using the Scientific Practices rubric or another rubric of your choosing that is appropriate for your local context.