LAB 19

Lab Handout

Lab 19. Differences in Regional Climate: Why Do Two Cities Located at the Same Latitude and Near a Body of Water Have Such Different Climates?

Introduction

Weather describes the current atmospheric conditions at a particular location. *Climate,* in contrast, is the aggregate or typical weather for a particular location over a long period of time. People often describe the climate of a region by reporting average temperatures and rainfall by month or by season. Cities located at higher latitudes (i.e., farther from the equator) experience greater changes in day length and Sun angle over the course of a year. These cities, as a result, have greater seasonal temperature differences than cities that are located closer to the equator. It is therefore not surprising that cities located at different latitudes often have very different climates. Cities located at the same latitude, however, can also have very different climates. A good example of this phenomenon is seen when we look at the climates of San Francisco, California, and Norfolk, Virginia (see Figure L19.1).

FIGURE L19.1

Locations of San Francisco and Norfolk

San Francisco is located on the coast of the Pacific Ocean at 37.7° N latitude. It has mild summers and winters; the average high temperature between 1945 and 2017 has been 17.1°C (62.8°F) for July and 9.7°C (49.4°F) for January. San Francisco is very dry, averaging 19.7 inches of rain per year from 1946 to 2017. (Climate information from the National Oceanic and Atmospheric Administration [NOAA] National Centers for Environmental Information is available at *www.ncdc.noaa.gov*.) According to the Köppen Climate Classification System (the most widely used system for classifying the world's climates; see *www.britannica.com/science/Koppen-climate-classification*), San Francisco has a temperate Mediterranean climate with warm summers (denoted Csb in the Köppen system). In contrast, Norfolk, which is located on the Atlantic Ocean at 36.9° N latitude, has hot summers and mild winters. The average high temperature between 1945 and 2017 has been 30.9°C (87.6°F) in July and 9.5°C (49.1°F) in January. Between 1945 and 2017, Norfolk has averaged 46.4 inches of rain a year. Norfolk has a humid subtropical climate (Cfa) based on the Köppen classification system. In summary, San Francisco and Norfolk have very different temperature and precipitation patterns throughout the year even though they are located at similar latitudes. To understand why these two cities have such different temperature and precipitation patterns, we must consider all the different factors than can affect the climate of a region.

There are at least six important factors to consider when someone attempts to explain a difference in two or more regional climates:

- *Latitude,* as noted earlier, determines changes in day length and sun angle throughout the year.
- *Elevation,* which is the height of an area above sea level. Generally, as elevation increases, temperature decreases.
- *Proximity to a large body of water.* Land heats up and cools down faster than water. Water can also store more heat energy than land. This makes the climate of a region that is located near a large body of water, such as an ocean, more moderate because the water absorbs extra heat energy during the summer and releases heat into the air during winter.
- *The nature of nearby ocean currents.* Ocean currents move large amounts of water with different properties to different locations across the Earth. Winds, tides, and differences in water temperature and salinity at different locations in the ocean affect the path an ocean current follows over time.
- *The direction and strength of prevailing winds.* Winds can move air masses with specific properties from a source region to a different region. In the Northern Hemisphere, winds tend to blow from west to east (westerly winds) in the mid-latitudes and northeast to southwest between the Tropic of Cancer and the equator.
- *Local topography.* The presence of absence of a mountain in a region, for example, can affect precipitation patterns and therefore climate.

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These six factors can help us understand why there are different climates at different locations around the globe. Yet, some of them may or may not be useful when we need to explain the different temperature and precipitation patterns observed in cities such as San Francisco and Norfolk. The two cities, as noted earlier, have much in common. San Francisco and Norfolk are located at similar latitudes, at an elevation slightly above sea level, and are near an ocean but on different coasts. You will therefore need to learn more about the nature of nearby ocean currents, the nature of any prevailing winds in these regions, and the local topography around these cities to figure out why these two cities have such different climates. Next, you will put all these pieces of information together to develop a conceptual model that not only explains the different climates in San Francisco and Norfolk but can also explain differences in the climates of other cities that are located at similar latitudes.

Your Task

Develop a conceptual model that you can use to explain the temperature and precipitation patterns in San Francisco and Norfolk. Your conceptual model must reflect what we know about the various factors that can affect climate, patterns, and systems and system models. To be considered valid or acceptable, you should be able use your conceptual model to not only explain why San Francisco and Norfolk have different climates but also to predict the temperature and precipitation patterns of several other pairs of cities that are located at similar latitudes on Earth.

The guiding question of this investigation is, ***Why do two cities located at the same latitude and near a body of water have such different climates?***

Materials

You can use the following online resources during your investigation:

- U.S. Climate Data. You can access this website, which includes detailed climate data and the location of most major U.S. Cities, at *www.usclimatedata.com/climate/united-states/us.*
- Wind rose data from the National Oceanic and Atmospheric Administration (NOAA). You can access this database, which includes monthly wind speed and direction information for 237 U.S. cities, at *www.climate.gov/maps-data/dataset/monthly-wind-rose-plots-charts*.
- *Earth: A Global Map of Wind, Weather, and Ocean Conditions.* You can access this interactive animated map that shows current wind speeds and direction for the entire planet at *https://earth.nullschool.net.*
- *My NASA Data*. You can access this database, which includes information about ocean surface temperatures and the average wind speed and direction by month over the entire year, at *https://mynasadata.larc.nasa.gov.*

- *State of the Ocean* (SOTO). You can access this visualization tool, which includes information about current and past ocean currents and changes in surface temperature, through the NASA Jet Propulsion Laboratory Physical Oceanography Distributed Active Archive Center at *https://podaac.jpl.nasa.gov.* Click on "Data Access" and "SOTO (State of the Ocean)" to open the visualization tool.

Safety Precautions

Follow all normal lab safety rules.

Investigation Proposal Required? ☐ Yes ☐ No

Getting Started

The first step in developing a conceptual model that explains differences in the temperature and precipitation patterns of San Francisco and Norfolk is to collect information about seasonal changes in temperature and precipitation in both cities. This information can be found at the U.S. Climate Data website. Be sure look for any patterns that you can use to help develop your conceptual model. Next, you can learn about the prevailing winds at each location using data provided by the NOAA wind rose website and the Earth: A Global Map of Wind, Weather, and Ocean Conditions website (which provides real-time data you can use). You can also access data about ocean temperatures and wind patterns by using the My NASA data. The final website, SOTO, will allow you to visualize a variety of ocean characteristics on a map of the world.

To learn more about how prevailing winds affect climate, you must first determine what type of data you need to collect, how you will collect it, and how you will analyze it. To determine *what type of data you need to collect,* think about the following questions:

- What are the boundaries and components of the system you are studying?
- How do the components of the system interact with each other?
- When is this system stable, and under which conditions does it change?
- What could be the underlying cause of this phenomenon?
- What type of measurements or observations will you need?
- What types of patterns could you look for in the available data?

To determine *how you will collect your data,* think about the following questions:

- What conditions need to be satisfied to establish a cause-and-effect relationship?
- How can you describe the components of the system quantitatively?
- What measurement scale or scales should you use to collect data?
- What type of comparisons will you need to make?
- How will you keep track of and organize the data you collect?

To determine *how you will analyze your data,* think about the following questions:

- What types of patterns might you look for as you analyze your data?
- How could you use mathematics to document a difference between conditions?
- What type of comparisons and calculations will you need to make?
- What type of graph could you create to help make sense of your data?

Once you feel you have gathered sufficient data and identified important patterns about how oceans and prevailing winds affect climate, your group can develop a conceptual model that can be used to explain why San Francisco and Norfolk have such different climates. To be valid or acceptable, your conceptual model must be able to explain

a. why San Francisco and Norfolk have such different seasonal temperatures, and
b. why San Francisco and Norfolk have such different rain patterns.

The last step in your investigation will be to generate the evidence that you need to convince others that your conceptual model is valid or acceptable. To accomplish this goal, you will use your model to predict the temperature and precipitation patterns in several additional cities. These cities should be ones that you have not looked up before but are located at similar latitudes on different coasts. Some good pairs of cities to compare are

- San Diego, California, and Charleston, South Carolina;
- Portland, Oregon, and Bangor, Maine;
- Eureka, California, and New York City; and
- Santa Monica, California, and Wilmington, North Carolina.

You can also attempt to show how using a different version of your model or making a specific change to a portion of your model will make your model inconsistent with data you have or the facts we know about climate. Scientists often make comparisons between different versions of a model in this manner to show that a model is valid or acceptable. If you are able to use your conceptual model to make accurate predictions about the climates of other cities or if you are able show how your conceptual model explains the climates of different cities better than other conceptual models, then you should be able to convince others that it is valid or acceptable.

Connections to the Nature of Scientific Knowledge and Scientific Inquiry

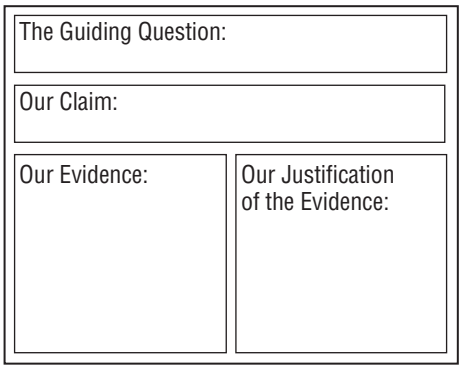
As you work through your investigation, be sure to think about

- how models are used as tools for reasoning about phenomena, and
- how the culture of science, societal needs, and current events influence the work of scientists.

Initial Argument

Once your group has finished collecting and analyzing your data, your group will need to develop an initial argument. Your initial argument needs to include a claim, evidence to support your claim, and a justification of the evidence. The *claim* is your group's answer to the guiding question. The *evidence* is an analysis and interpretation of your data. Finally, the *justification* of the evidence is why your group thinks the evidence matters. The justification of the evidence is important because scientists can use different kinds of evidence to support their claims. Your group will create your initial argument on a whiteboard. Your whiteboard should include all the information shown in Figure L19.2.

FIGURE L19.2
Argument presentation on a whiteboard



Argumentation Session

The argumentation session allows all of the groups to share their arguments. One or two members of each group will stay at the lab station to share that group's argument, while the other members of the group go to the other lab stations to listen to and critique the other arguments. This is similar to what scientists do when they propose, support, evaluate, and refine new ideas during a poster session at a conference. If you are presenting your group's argument, your goal is to share your ideas and answer questions. You should also keep a record of the critiques and suggestions made by your classmates so you can use this feedback to make your initial argument stronger. You can keep track of specific critiques and suggestions for improvement that your classmates mention in the space below.

Critiques of our initial argument and suggestions for improvement:

If you are critiquing your classmates' arguments, your goal is to look for mistakes in their arguments and offer suggestions for improvement so these mistakes can be fixed. You should look for ways to make your initial argument stronger by looking for things that

the other groups did well. You can keep track of interesting ideas that you see and hear during the argumentation in the space below. You can also use this space to keep track of any questions that you will need to discuss with your team.

Interesting ideas from other groups or questions to take back to my group:

Once the argumentation session is complete, you will have a chance to meet with your group and revise your initial argument. Your group might need to gather more data or design a way to test one or more alternative claims as part of this process. Remember, your goal at this stage of the investigation is to develop the best argument possible.

Report

Once you have completed your research, you will need to prepare an investigation report that consists of three sections. Each section should provide an answer for the following questions:

1. What question were you trying to answer and why?
2. What did you do to answer your question and why?
3. What is your argument?

Your report should answer these questions in two pages or less. You should write your report using a word processing application (such as Word, Pages, or Google Docs), if possible, to make it easier for you to edit and revise it later. You should embed any diagrams, figures, or tables into the document. Be sure to write in a persuasive style; you are trying to convince others that your claim is acceptable or valid.