# Activity II: Using Statistics to Understand How Weather Varies With Time and Position

## Introduction

Students use databases in this section to analyze trends between weather characteristics and position, in order to make generalizations about how the weather systems work globally and for smaller regions. **Activity II: Using Statistics to Understand How Weather Varies with Time and Position** challenges students to use several statistical tests to compare various measurements correlated to weather. Students begin at a global scale in **Part A - Analyzing the Relationship Between Latitude and Weather Features**, then proceed to look at smaller regions in the Northern and Southern Hemispheres. Students use United Kingdom data sets to investigate the relationship between time and position more specifically, for regions of the United Kingdom. They refine their study in **Part B - Analyzing Patterns in Weather Across Towns in the United Kingdom**, when they look at specific town data. Students are asked to consider adequate sample sizes and change across time, **Part C - Measuring Weather Changes Across Years in Regions of the United Kingdom**. Trends are explored further in Belgium, using their meteorological weather database, to decide for **Part D - Can We Extend Generalizations to Europe?** Students address a more sizable land mass and a different hemisphere, when they use Australian meteorological data to answer questions about correlations between weather-related information. They can also re-explore possible trends here, which might have been statistically insignificant in smaller regions with smaller data sets. **Part E - Analyzing Australian Data** also reminds students to be analytical of the data collection processes. Use of the SOI index reinforces the notion that weather is a global process and is not limited to the land region where it may be measured. Finally, an American database is used, albeit a small one, in **Part F- What's Weather Like in North America?** Students use American and Canadian web site databases to make conclusions about relationships between weather-related variables. Students sum up their research by planning journeys, complete with maps, detailed logs, and story boards for four separate months of travel in **Part G - Planning a Global Trip**.

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### Part A - Analyzing the Relationship Between Latitude and Weather Features

In this section, you will analyze weather data to look for trends across positions, times, and weather types.

1. Reach the Surface Temperature database by going to http://www.giss.nasa.gov/data/update/gistemp/station-data/

   Click on the map to obtain surface temperature information from around the globe!

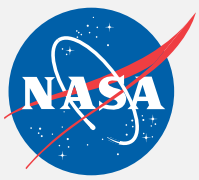
2. Collect 10 data points for every 10 degrees of latitude (both Northern and Southern hemispheres). You will need to use maps to obtain latitude information.

3. Plot latitude versus temperature; you will want to use negative values for the Southern Hemisphere OR use only positive values and plot the hemispheres in different colors.

4. What is the pattern you see?

5. Obtain world data for precipitation, wind speed, pressure, and other weather features, and produce similar graphs.

6. Can you draw correlations between certain weather characteristics? Create a correlation matrix or a linear graph to look for a trend.

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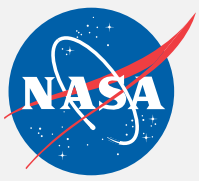
7. Why, based on the scientific principles behind each feature, are some weather traits related (inversely or directly)?

8. Can you write an approximate linear or non-linear equation that approximates the relationship between any two variables? Test this equation by obtaining new data from another source and determining the proximity of your estimate to the actual values to the estimates on your line.

9. How might a relationship between two weather features be advantageous for meteorologists, pilots, or anyone else needing to predict weather?

10. Analyze the relationships you have discovered using various statistical methods. Report your findings using prose, charts and graphs, mathematical equations, and examples. (Talk to your teacher for specific features of your analysis.)

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### Part B - Analyzing Patterns in Weather Across Towns in the United Kingdom

Americans make generalizations about weather across states (for instance, Washington is the rainiest, Oregon is slightly less rainy, California is sunny, etc.). Can we make generalizations about weather across smaller or larger geographic regions? You saw a correlation between latitude and some weather characteristics, previously. In the following sections we will investigate such correlations in more detail.

The United Kingdom supplies long-term statistics categorized by month and year, in maps, charts, and text form at http://www.met-office.gov.uk/education/data/climate_time.html (1961 - 2001) and http:www.metoffice.com/climate/uk/index.html (1998-2001 only).

Use this data and a map that shows distance, longitude, and latitude, to make comparisons of weather across small regions. Start with the 1961 - 90 Station Averages arranged by month and year.

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1. Choose the towns you will compare. You will collect data from 1 town from each of the geographic regions shown in the following chart. The regions in the chart run from North to South (Central North is half way between Noth Mainland and Central Mainland).

   a. Record the name of your town, the elevation, and the National Grid Reference (this is a bit more specific than latitude and longitude in most cases). These are available from the web site.

   b. Record the longitude and latitude for your towns. You will need to obtain these from another map.

| | Geographic Region | Town | (Longitude, Latitude) | Natl. Grid Reference | Elevation |
|---|---|---|---|---|---|
| 1. | North Isles | | | | |
| 2. | North Mainland | | | | |
| 3. | Central North | | | | |
| 4. | Central | | | | |
| 5. | Central South | | | | |
| 6. | South | | | | |

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2. Collect temperature data for each month, for each place, and create a scatter plot.

   a. Place temperature on one axis (be consistent with what you did in the last section) and latitude on the other axis. If you were unable to obtain exact latitude data, include the National Grid Reference data (North or South value only) instead of the latitude.

   b. Be sure to use simple, legible symbols for each town or region.

   c. You may connect the dots to make your scatter plot more readable.

   d. Include a small chart to the right of your scatter plot, showing how Celsius values relate to Fahrenheit values, for reference.

3. Describe the pattern, if there is any, for North / South direction and temperature. Further analyze the pattern using other statistical means.

4. Create a scatter plot for another weather trait that you felt was related to latitude and longitude in the previous activity. Describe the pattern, if there is one. Further analyze the pattern using other statistical means.

5. Compare temperature data for each month against E/W position (from the National Grid Reference). Repeat #2, 3, and 4 for this data set.

6. Compare temperature data for each month against altitude. Repeat #2,3, and 4 for this data set.

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7. Compare your data with the remainder of the class to discover if there may be other sets of data that do or do not show trends. Discuss outliers and other ways of analyzing the data, in order to account for such things as:

   a. exposure to the elements from one or more directions (islands versus mainland)

   b. relation to mountains (rain shadow effect)

   c. distance inland

   d. relations to ocean currents

   e. small data sets

   f. small ranges of data (e.g. East / West data versus North / South data)

8. Consider the kinds of weather data this database provides.

   a. How does its inclusion or exclusion of certain weather characteristics reflect the culture and climate of the area?

   b. If you were packing for a trip here, what would you pack? A wind breaker? Galoshes? Sun glasses?

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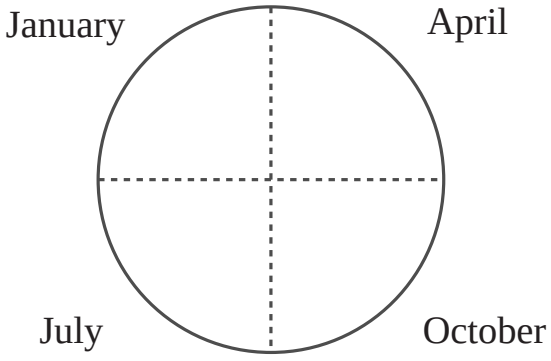
9. In some regions, airports plan for higher and lower airport capacity, based on weather (see **Airport Research section II web site reading regarding Portland, Oregon**). If the average capacity was 100 flights per hour, and it was cut in half by poor weather conditions (rain, heavy cloud cover, mild wind storm), then how would the average airport capacity look for the regions you studied, in January, April, July, and October?

Record these in a circle like that which follows (put the flight capacity estimate in the quarter circle), placed on the region that you researched, on a map.



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### Part C - Measuring Weather Changes Across Years in Regions of the United Kingdom

1. We have a sense of how weather changes with position, and how it may or may not change on a small scale. All of the conclusions we have made thus far are based on single data sets that are either a composite of several years or of a single period of time. This may cause statisticians some concern. Why?

We certainly want to see if conclusions about weather and position are maintained when we study multiple data sets across time. Studying a variety of data sets from different years should provide us with a larger data set and help convince (or not convince) us of any trends.

2. Go to the web page at http://www. met-office.com/climate/uk/index.html and look at yearly summaries for the different months of the year and for different United Kingdom regions. The web site should have every month in 1998, 1999, 2000, and 2001. It is recommended that you access information from tables, rather than from maps and charts, which can be a bit more confusing.

3. Create a scatter plot to compare temperature (one axis) and location (average latitude or North / South direction, for example) for all three years. Include a legend or key so it is clear which year is which.

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4. Do all of the years show the same pattern? If they do not, propose a reason why they are different. Was there a weather anomaly (e.g. El Niño) that year?

5. Sketch in error bars (anomaly values) to take into account the range for any region. Based on error, are all years consistent? Are there still outliers that might be explained by some strange weather occurrence?

6. Based on this comparison, do you believe you could accurately predict what the weather will be like for pilots flying in the following regions at the following times? Explain why or why not using the following table.

| Time of Flight | Northern Ireland | East Anglia | Midlands |
|---|---|---|---|
| Spring, next year | | | |
| October, next year | | | |
| July 14, next year | | | |
| 12:30pm, January 5, next year | | | |

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7. What additional resources would you want to use, to help you make your decision?

8. As required, do further graphical or statistical comparisons between the regions in the United Kingdom and weather characteristics.

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### Part D - Can We Extend Generalizations to Europe?

Belgium has a very nice weather site which we can use to determine if we can extend generalizations about weather and position to other regions in Europe. Visit http://www.meteo.oma.be/IRM-KMI/climate/climate.html
They have data organized by month (recent only), season (recent four only), and year.

1. Open a summary of the previous month. What are the column headings, and what do they mean?

2. Why might the + and - headings be important, for a traveler or pilot, who was planning a journey for the next year? Consider the fact that the Belgium data-base does not contain weather data from more than a year ago.

3. Based on what you see in the YEAR columns and car section, what might be the advantages of weather forecasting in Europe, versus America?

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4. What weather characteristics are included in this web site that are not in the United Kingdom site? What does this indicate to you about the culture and climate of this region?

5. Use the maps to draw conclusions about position in Belgium and different weather characteristics for the month. Complete the following sentences with your generalization(s) and at least one specific example each. You may have to refer to a map that shows altitude, longitude and latitude, and other ground features, to make your conclusions.

**For temperature:**

a. As one moves from North to South

example:

b. As one moves from East to West

example:

c. As one moves from lower altitude to higher altitude

example:

d. As one moves from lateral to medial

example:

e. other? (you decide)

example:

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**For precipitation:**

a. As one moves from North to South

example:

b. As one moves from East to West

example:

c. As one moves from lower altitude to higher altitude

example:

d. As one moves from lateral to medial

example:

e. other? (you decide)

example:

6. Make the same kinds of conclusions for another month or time period.

**For temperature:**

a. As one moves from North to South

example:

b. As one moves from East to West

example:

c. As one moves from lower altitude to higher altitude

example:

d. As one moves from lateral to medial

example:

e. other? (you decide)

example:

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**For precipitation:**

a. As one moves from North to South

example:

b. As one moves from East to West

example:

c. As one moves from lower altitude to higher altitude

example:

d. As one moves from lateral to medial

example:

e. other? (you decide)

example:

7. How could you more mathematically arrange and analyze the data from questions 6 and 7, so you could compare position with a weather feature, statistically or with the use of a method used in the last activity? Create a new way of presenting this information, using your idea(s).

8. How does this data compare with the United Kingdom data sets and the World latitude data set?

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9. If you were to investigate this further, what kind of Belgium information would you need? What qualities would you desire in your data?

10. Use the season data in a way similar to how you used the monthly data sets.
    a. Before you begin, use the reference periods icon on the season page or the heading in the chart to determine how closely a given month (e.g. April) will align with a season. How might we remedy any misalignment or make the UK and Belgian data sets more similar?

    b. On the position / time graph, plot a single point for each season, aligning with the appropriate month on the UK scatter plot, using the latitude and longitude of the center of Belgium as your position. How do the Belgium values fit with your UK plot?

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c. Based on the data for the 4 seasons you observe, what is the probability that in Belgium on a record-making…

i) dry year, it also has the fewest rain days

ii) wet year, it also has the most rainy days

iii) dry year, it is also the sunniest

iv) dry year, it is the sunniest and has the fewest rainy days

v) dry year, it is the warmest

vi) wet year, it is the coldest

Would one conclude that extreme weather traits are or are not correlated from this data? Why would a statistician be hesitant to make such a conclusion?

d. Based on the "Line Characteristics" in the seasonal graphs, plot the temperature and month / year on a scatter plot.

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Estimate temperatures for the past 150 years, based on the present season's temperature. Do the record years align with your prediction?

If you wanted to plan a flight to Belgium when the weather was pleasant, when would you plan to go?

If you wanted to visit in 5 years, what would you predict the temperature to be?

11. Use the climatological summary of the year to get a sense of how weather traits change across time, in Belgium.

    a. What are the features of the charts for this section, and what do they mean? Draw an example chart and point out important features. Include units where appropriate.

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b. Why are multiple years shown in this chart? What advantage does it serve, instead of showing just one year?

c. Why are some years not shown?

12. Use the values provided in the charts to produce values per month for the year, which can be placed on the UK chart (use a new color) showing position and a temperature trait. You can use the latitude of central Belgium as your position.

13. How do the Belgium values compare to the UK values?

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14. Which do you prefer - the monthly values or the seasonal values, and why?

15. The plot of sunshine duration across a year produces a nice curve.
    a. Approximate an equation for that curve.

    b. If you were planning a trip in August, use your equation to approximate the sunshine duration.

    c. A physicist might anticipate that a curve like the one you observe would occur, based on the time of year. Explain what he means.

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16. Temperature appears to make a curve as well.
    a. Approximate this curve with an equation.

    b. How are the two curves (for sunshine and temperature) related? Are they dependent or independent? Explain.

    c. If you were piloting a plane that was leaving Brussels in December, what would you expect the temperature to be?

    d. If 1879 data represents an abnormality that is predicted to occur every 40 years, when should pilots set aside time to either de-ice their planes or cancel flights, due to extremely low temperatures.

## Part E - Analyzing Australian Data

1. Visit the Bureau of Meteorology in Australia at http://www.bom.gov.au/climate/ They provide information on averages and extremes. Enter this portion of the website by clicking the appropriate button, then read "accompanying notes".

   a. What are some ways that the program prevents bias?

   b. How might the data be biased?

   c. What is a decile? Use a picture or example to help you explain.

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2. Use the Climate Glossary in the Climate Information section at this web site to investigate the term SOI.
   a. What is the SOI and what does it represent?

   b. Sketch a small map that indicates where this index is relevant. Shade in the approximate area that is affected by this phenomenon.

   c. When the SOI is positive, what does it mean? What does it mean when it is negative?

   d. What does the Australian Bureau of Meteorology do to calculate the SOI?

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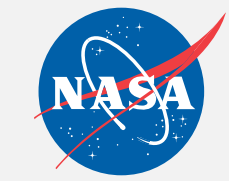
e. What were the SOI values for the past year? Which patterns would you expect, based on seasons? Do they agree with what you see? (Hint: Remember, Australia is in the Southern hemisphere.)

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### Part F - What's Weather Like in North America?

1. Research daily or monthly weather patterns for the past twelve months, compared to norms established over the last century, at www.wrh.noaa.gov/wrhq/nwspage.html.
   This site links to the National Weather Service Homepages for NWS Offices and Forecast Offices all over the country. Use the map that appears to select a region. Then go to "Climate Data" and select the month or time period you would like to study.

   You can also obtain surface temperature information from other states in the United States at http://www.giss.nasa.gov/data/update/gistemp/station_data/

   Canada has weather information at http://www.cmc.ec.gc.ca/climate/normals/eprovwmo.htm

   a. Compile the data just as you did for the United Kingdom, Belgium, and Australia and use it to potentially reinforce generalizations you have already made or to investigate trends you may have seen. Document your findings, using statistical values, equations, graphs, and other appropriate information.

   b. If you were a pilot, what kinds of precautions, predictions, and preparations would you make, when flying to Alaska at 4 different times of the year? Describe your four scenarios in paragraphs and provide specific examples or data to defend your precautions, predictions, and preparations.

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### Part G - Planning a Global Trip

Plan a trip that includes stops at all four locations you have researched (United Kingdom, Belgium, Australia, North America) plus two new regions you have not researched. Do the following:

1. Use an aeronautical chart or map to determine course heading, distance, time, and required fuel for your flight. Keep in mind that an airplane's tank can only hold a finite amount of fuel, so distances between stops should be appropriate for gassing-up. A Boeing 737-376 airplane can hold 5,311 gallons or 20,105 litres of fuel, and travel 1.167 nautical miles per gallon or 0.308 nautical miles per liter. Draw a simple map showing your path, stops, and landmarks along the way (other city names or topographical features like mountains or waterways).

2. Determine the weather conditions for each landing /take off as well as at regions of topographical or climatical significance (moving from ocean to land or passing over mountain ranges, for example). Plan for four different flights: in April (Spring), in August (Summer), in October (Fall), and in January (Winter). Access weather information from the web sites you have used previously or one of the following web sites that provide international weather information.
   http://www.worldclimate.com
   http://www.intellicast.com/Travel/World/
   Record and use current and historical data to explain your decisions about predicted weather patterns for the times that you will be in each region. Note if special conditions may arise, either due to an anniversary of an aberrant condition (100th anniversary of a 100-year storm, for example), or because of a mix of weather conditions (low temperatures and high humidity and hence icing, for example). You may use weather information that is implied if data is missing or only available for a neighboring region. In either situation, be sure to explain how the information was collected. The following web site has surface temperature information only for international regions (including oceans), if the previously mentioned sites are not useful.
   http://www.giss.nasa.gov/data/update/gistemp/station-data/

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3. Fill in the following log. Include all important weather information you collected in #2 (for landings and take offs as well as over regions of topographical significance).

**Time elapsed** should start at zero and measures the time since initial take off.

**Local time** refers to the time at the location where the airplane is.

**Coordinates** should be in terms of longitude and latitude.

**Approximate Location** should refer to a geographic location by name.

**Fuel amount** will start at full; assume you are flying a Boeing 737-376 airplane.

**Weather** should be as complete as possible; in the event that approximations are made, justify them with a written statement, as described in #2.

The **Caution** column should be filled with information about the need to check for threatening weather systems or other situations that could result in problems. This column should only be filled in when necessary.

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Name: Date:

| Flight No. 1 - January_____ (year) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Date | Time Elapsed | Local Time | Location Name | Coordinates | Fuel Amount | Weather | | | | Alerts |
| | | | | | | temp | precip | wind speed & dir | baro. pressure | |
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Name: Date:

**Flight No. 2 - April _____ (year)**

| Date | Time Elapsed | Local Time | Location Name | Coordinates | Fuel Amount | Weather | | | | Alerts |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | temp | precip | wind speed & dir | baro. pressure | |
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Name: Date:

| Flight No. 3 - August _____ (year) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Date | Time Elapsed | Local Time | Location Name | Coordinates | Fuel Amount | Weather | | | | Alerts |
| | | | | | | temp | precip | wind speed & dir | baro. pressure | |
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Name: Date:

| Flight No. 4 - October_____ (year) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Date | Time Elapsed | Local Time | Location Name | Coordinates | Fuel Amount | Weather | | | | Alerts |
| | | | | | | temp | precip | wind speed & dir | baro. pressure | |
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4. Create a story board of your journey. In each frame, draw your plane, you, and indicate weather conditions. Also indicate time of day and date. Beneath each frame, include a map to show where you are OR include a large map to show your journey and the position for each frame, alongside your storyboard.