CHICAGO BOTANIC GARDEN

Activity 2.3: Climate Change Around the World

Grades 7 – 9

Materials
- Student handouts
- Computer with internet access
- Pens or pencils
- Overhead projector (optional)
- Printer (optional)

Description: Up until now, students have focused only on temperature when evaluating the impacts of climate change. Now, through a brainstorm and discussion, students will discuss and add other climatic factors to their analysis and investigate how changes in atmospheric carbon dioxide levels impact not only temperature, but can also create changes in regional precipitation and cloud cover.

Students then use the MY NASA DATA website to determine whether global patterns of climate change are directly reflected in their city and in cities around the world. They discuss why different locations around the world are affected differently or to different degrees by changing climates

Optional: Students can investigate the occurrence of extreme weather events (precipitation, hurricanes, temperature extremes etc.) outside of MY NASA DATA at NOAA's National Climatic Data Center: http://www.ncdc.noaa.gov/climate-information/extreme-events. The NCDC Climate Extremes Index graph generator: http://www.ncdc.noaa.gov/climate-information/extreme-events allows student to select the type of extreme event they are interested in, and then generate a graph of the occurrences of that event by year starting in 1910. Graphs are in percentage difference from the mean. Additional information can be found at NCDC: http://www.ncdc.noaa.gov/extremes/.

Total Time: Two to three 45-minute class periods

National Science Education Standards
A1.D Develop descriptions, explanations, predictions, and models using evidence.
A1.E Think critically and logically to make the relationships between evidence and explanations.

AAAS Benchmarks
4B/M14: The Earth has a variety of climates, defined by average temperature, precipitation, humidity, air pressure, and wind over time in a particular place.
4B/H5 Climatic conditions result from latitude, altitude, and from the position of mountain ranges, oceans, and lakes. Dynamic processes such as cloud formation, ocean currents, and atmospheric circulation patterns influence climates as well.

Guiding Questions
- What variables make up climate, in addition to temperature?
- How are climate variables changing over time in individual cities?
- How do these variables compare across different cities throughout the world?
- How can we use NASA and NOAA climate data to represent changes in global and regional precipitation, temperature, and cloud cover?

- What are the changes in average temperatures, precipitation, and cloud cover over time in different regions around the world, and how do those change compare to those variables on our home city?
- Are global changes in climate variables (temperature, precipitation, and cloud cover) different across regions? What are the differences and similarities of the impacts of climate change on regions around the world?

Assessment(s)
- Graphs generated from MY NASA DATA
- Climate Change Around the World Worksheets

Background Information
Palmer Drought Severity Index is a meteorological drought index developed in 1965 by Wayne Palmer to measure the departure of the moisture supply. Palmer based his index on the supply and demand concept of the water balance equation, taking into account more than just the precipitation deficit at specific locations. Developed for the United States and tested using the regional climates of the country, the objective of the PDSI was to provide measurements of moisture conditions that were standardized so that comparisons using the index could be made between locations and between months. It uses temperature and precipitation data to calculate water supply and demand, incorporates soil moisture. It primarily reflects long-term drought and has been used extensively to initiate drought relief.

The Palmer Drought Severity Index (PDSI) is a standardized index that spans -10 (dry) to +10 (wet). It has been reasonably successful at quantifying long-term drought. As it uses temperature data and a physical water balance model, it can capture the basic effect of global warming on drought through changes in potential evapotranspiration. Monthly PDSI values do not capture droughts on time scales less than about 12 months.

Strengths:
- Effective in determining long-term drought, especially over low and middle latitudes
- By using surface air temperature and a physical water balance model, the PDSI takes into account the basic effect of global warming through potential evapotranspiration
- Takes precedent (prior month) conditions into account

Limitations:
- Not as comparable across regions as the Standardized Precipitation Index (SPI), but this can be alleviated by using the self-calibrating PDSI
- Lacks multi-timescale features of indices like the SPI, making it difficult to correlate with specific water resources like runoff, snowpack, resevoir storage, etc.
- Does not account for snow or ice (delayed runoff); assumes precipitation is immediately available

Despite its limitations, PDSI values are significantly correlated with measured soil moisture content in the warm season and streamflow over many regions over the world, and satellite observed land water storage changes, and these correlations are comparable over the United States and many other parts of the world. This is largely due to the fact that the normalization in the Palmer model minimizes the errors associated with many of the assumptions made by Palmer [1965] and that actual evaporation is often determined, to a large degree, by the availability of soil moisture (and thus is affected by precipitation), not only by potential evapotranspiration, over many land areas. Also, using annual values should minimize the seasonal effect of snowfall on the surface water balance.

The PDSI has been criticized for its inability to depict droughts on time scales shorter than 12 months when monthly PDSI values were used. However, PDSI is based on a physical water-balance model, uses both precipitation and surface air temperature as input, and takes the precedent condition into account, in contrast to most other drought indices that are based purely on past statistics of certain climate variable(s), which often includes precipitation alone. From this perspective, the PDSI may be considered superior to other statistically based drought indices. This is because the PDSI can account for the basic effect of global warming through Palmer's water balance model on droughts and wet spells.

Adapted from:
- https://climatedataguide.ucar.edu/climate-data/palmer-drought-severity-index-pdsi
- http://drought.unl.edu/Portals/0/docs/workshops/03222012_Kingston_Jamaica/Brian%20Fuchs--PDSI%20and%20scPDSI.pdf
- http://www.drought.gov/drought/content/products-current-drought-and-monitoring-drought-indicators/palmer-drought-severity-index

Pre-Activity:
- Familiarize yourself with the MY NASA DATA website http://mynasadata.larc.nasa.gov/las/getUI.do.
- Review the NOAA Paleoclimatology website to learn about weather events and climate trends over the past 100 years. http://www.ncdc.noaa.gov/paleo/ctl/100.html

Procedure:
1. Review the conclusions of Activity 2-3. Discussion questions might include:
    - What did looking at past temperatures tell us about temperature over very long periods of time? (it changes slowly, naturally)
    - What was different about our graph of temperatures over the past 100 years from the rest of the historical temperature graphs that we looked at?

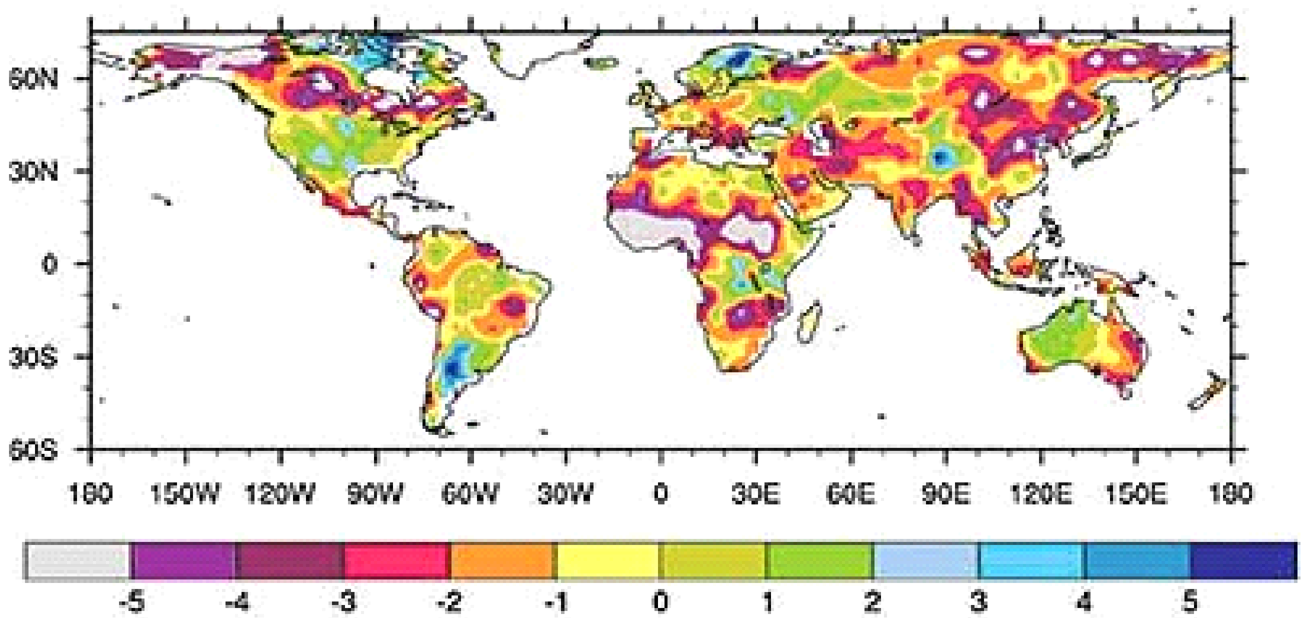
2. Transition the discussion to other aspects of climate. Write answers on the board, so students can refer to them during their investigation. Discussion questions might include:
    - We've looked only at temperature so far, what are other elements that make up climate? (precipitation [how much and when], cloud cover)
    - Do you think these elements of climate might change if the climate changes? In what ways might they change? (more/less rain, etc.)
    - Have they changed globally? What about in our city and in other cities around the world? Do you think the changes would be the same everywhere in the world?
    - What data would we need to find out whether precipitation and cloud cover have changed?

3. Tell students that they are going to use real data from NASA to find out whether other climate factors have changed, in addition to temperatures, in their city and in other cities around the world.

4. Assign or allow students to choose a city. **<u>Make sure one group of students has the city in which your school is located</u>**. The map below will help you find cities that will illustrate the contrast across regions. Some suggestions that provide interesting comparisons are:

Your School's City/State

Alice Springs, Australia	Brisbane, Australia	Neuquen, Argentina
Gurupi, Brazil	Edmonton, Canada	Iriba, Chad
Beijing, China	Shanghi, China	Nzerekore, Guinea
New Delhi, India	Noril'sk, Russia	El Obeid, Sudan
Edmonton, Canada	Iriba, Chad	Phoenix, Arizona, U.S.
Houston, Texas, U.S.		



This depiction of linear trends in the Palmer Drought Severity Index from 1948 to 2002 shows drying (reds and pinks) across much of Canada, Europe, Asia, and Africa and moistening (green) across parts of the United States, Argentina, Scandinavia, and western Australia. (Illustration courtesy Aiguo Dai and the American Meteorological Society.)

5. Distribute the "**Climate Change Around the World**" instructions and handout to students.

6. Break students into groups of two to three per computer and walk them through the creation of the first graph so they have the idea. Then have them complete the other graphs and their worksheets.

7. Give students at least 30 to 40 minutes to generate their graphs. They may need assistance in figuring out the MY NASA DATA site, even if they are familiar with computers.

8. Once students have created their graphs and done their analysis, bring the class back together for the closing discussion.

9. Discuss the results of their graphing activity. Begin with the group that analyzed the data for your home city and state and have them report back their results and write them on the board. Begin a full class discussion of the results for their home city and compare them with the data from other cities. Discussion questions might include:
   - Did you see trends in your data? (because the data is fairly short term, trends may not be immediately obvious)
   - Are the trends from our city consistent with the U.S. data?
   - Are trends from other locations consistent with U.S. data?
   - Why might they be different?
   - Are there any patterns in the trends?
   - Are different climates, regions, or continents, reacting differently to the increase in global temperature?
   - What might be some impacts on the lives of the people who live in different areas of the world that have different trends? (e.g. people who live in places with less or more precipitation, on coasts, etc.)

10. Summarize by emphasizing that climate change is not simply temperature increase, but because all the Earth systems interact with each other, it affects other aspects of climate, precipitation and cloud cover. Lab sheets may be collected as an assessment, and should be placed in student portfolios.

NOTE: If you do not have time to implement all four units of the curriculum, you may skip to the concluding activity “Faces of Climate Change” (Activity 4.2) to illustrate the impacts of changing climates on people around the world.

Useful Internet Resources:
http://www.nws.noaa.gov/om/severeweather/index.shtml (Severe Weather Safety)
http://www.nssl.noaa.gov/ (National Severe Storms Laboratory)
http://weather.about.com/od/thunderstormsandlightning/u/severestorms.htm (About.com)
http://severe.worldweather.wmo.int/ (World Meteorological Organization)
http://www.weather.com/homepage.html (The Weather Channel)
http://data.giss.nasa.gov/precip_dai/ (NASA global precipitation data)

Directions: Climate Change Around the World

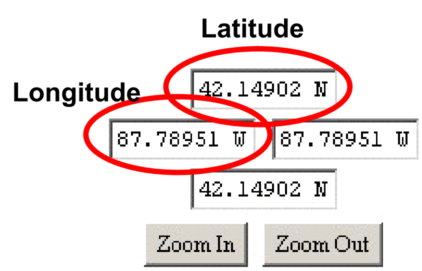
Use NASA data to make the same type of graph for your location.

1. **Find the latitude and longitude of the city you will be researching and record it on your worksheet.**
    a. Use the Geocoder at http://www.latlong.net/convert-address-to-lat-long.html
    b. Type the city, and country into the text box above the map
    c. Click the **GEOCODE** button
    d. The latitude and longitude of you city will be displayed above the map
    e. Write the latitude and longitude, including the direction (north/south for latitude and east/west for longitude)

2. **Generate your graphs**

Part A: Temperature

1. Open your web browser and go to the MY NASA DATA website. Either typing in the following address http://mynasadata.larc.nasa.gov/las/getUI.do, or clicking on the desktop link your teacher has created.
2. The **DATASETS** window will open automatically
3. Click on the ✚ sign next to "Land Surface"
4. Click on the ✚ sign next to "Surface Conditions"
5. Select **Monthly Surface Clear-sky Temperature (ISCCP)**
6. Select **Time Series** under the **Line Plots** header
7. Select the full time range available
8. Enter your latitude in the **top** text box and the longitude in the **left** text box to the right of the map.
9. Click the checkbox on the **UPDATE PLOT** button on the far left of the top menu bar. This will update your graph and make sure that your graphs update as you make selections for precipitation, cloud cover, and carbon dioxide.
10. Your graph will update on the right side of the web page



11. Click on the **PRINT** button on the far right of the top menu bar, this will show your graph in a separate window
12. Print or save your graph

    To PRINT your graph
    a. Select **File** then **Print** from the top menu on your web browser
    b. A print options box will open
    c. Your teacher will give you instructions on what printer and options to select

    To SAVE your graph
    a. Select **File** then **Save As** from the top menu on your web browser

b. Select **Desktop** from the "Save in" drop down menu
c. Type the name of your graph in the **File Name** text box. Name your graph so that you will know what is in the file.
   - Begin the file name with your name or your initials, so you know it is your file.
   - Leave a space.
   - Then type the climate variable the graph represents (Temperature, Precipitation, Cloud Cover or CO_2).

     Example: JSB Temperature

d. Select the file type: WEB ARCHIVE, SINGLE FILE (*.mht)
e. Click **SAVE**
f. The file will appear on your desktop

Part B: Cloud Cover
1. Click the **CHOOSE DATASET** button on the far left of the top menu bar.
2. Click on the ✚ sign next to "Atmosphere"
3. Click on the ✚ sign next to "Clouds"
4. Click on the ✚ sign next to "Cloud Coverage"
5. Select **Monthly Cloud Coverage (ISCCP)**
6. Select the full time range available

Follow steps 9-12 to print or save your graph

Part C: Precipitation
1. Click the **CHOOSE DATASET** button on the far left of the top menu bar.
2. Click on the ✚ sign next to "Atmosphere"
3. Click on the ✚ sign next to "Precipitation"
4. Select **Monthly Precipitation (GPCP)**
5. Select the full time range available

Follow steps 9-12 to print or save your graph

Part D: Carbon Dioxide
1. Click the **CHOOSE DATASET** button on the far left of the top menu bar.
2. Click on the ✚ sign next to "Atmosphere"
3. Click on the ✚ sign next to "Air Quality"
4. Select **Monthly Carbon Dioxide in Troposphere (ARIS on AQUA)**
5. Select the full time range available

Follow steps 9-12 to print or save your graph

Name:______________________________ Date:____________ Room:__________

Expanding the Climate Model

Answer questions 1-5 as a group using the graphs you generate. Answer questions 6 and 7 from the following class discussion.

Part 1: Researching your city

1. Write the name of the city and country that you are researching, and their latitude and longitude below

   City, Country: ____

   Latitude:______________________________ Longitude: ______________________________

2. From your graphs, can you determine any trends in temperature, precipitation and cloud cover in the city you are researching? Discuss each graph separately.

   Temperature trends:

   Precipitation trends:

   Cloud cover trends:

3. What can you determine from the graph of CO_2 in the atmosphere?

4. How do your CO_2 and climate variable graphs compare? What conclusions can you draw, if any? Use your data to support these conclusions.

5. Based on your data, what do you predict will happen to the climate in your city in the future?

Part 2: Comparing across cities

6. Compare your city's graphs with at least one other group of students. Note their city, and describe how your temperature, precipitation, and cloud cover graphs compare to theirs. Use the data to explain your answers.

   Comparison city and country: ____

   Temperature comparison:

   Precipitation comparison:

   Cloud cover comparison:

7. Is the climate changing in the same way in both your cities? What does your data tell you about how climate is changing globally?

Part 3: Global Comparisons

Answer the following questions as you discuss the results of your data analysis as a class.

8. Based on the data that you and your classmates have analyzed, describe the similarities and differences in trends in temperature, precipitation, and cloud cover around the world. Support your answer with examples from your discussion.

9. Based on the data that you and your classmates have analyzed, describe the similarities and differences in trends in carbon dioxide around the world. What conclusions can you draw?

10. You've heard the term "Global Warming" to describe changing climates. Explain why "Climate Change" is a more accurate way of describing what is happening to climate today.

11. What might be some impacts on the lives of the people who live in different areas of the world that have different trends?

