Overview of the Weather to Climate Learning Progression

Focus: Explore the concepts of weather and climate using local weather data and global climate data.

Rationale: The goal of this sequence is to provide students with a bridge between the study of weather and the study of climate and global climate change that is grounded in the students' experience and environment. The Weather to Climate Learning Progression begins with an exploration of a long-term local weather dataset from Daymet, which provides daily climatological data from the Oak Ridge National Laboratory Distributed Active Archive Center (ORNL-DAAC). Depending on the level of inquiry, students explore provided datasets, or download and prepare their own. They are then able to use Climate Change Visualization Tools to compare their local findings with future climate predictions at this location, and climate patterns across the globe.

Part 1. Explore local Daymet weather data using Excel (or a similar spreadsheet tool).

- What are the historical and/or current weather patterns or events for a location in North America?
- What are the long-term weather patterns (i.e. climate) in these locations?

Part 2. Use the Climate Change Visualization Tools (Single Site Climate Data, Climate Maps, Temperature and Precipitation Animations) to compare and contrast historical/current data with future predictions, and local data with global data.

- Will the weather and climate patterns I observed in the local data continue into the future?
- How do local climate patterns compare to other regions of the world?

Pre-requisites:

1. (Optional) Measure and record local weather data at your school.

2. Some experience with Excel. For an Excel tutorial see: http://www.fgcu.edu/support/office2007/excel/index.asp

Part 1. Local Weather Data

Guiding Questions:

- What are the historical and/or current weather patterns or events for a location in the United States?
- What are the long-term weather patterns (i.e. climate) in this location?

Definitions:

- **Weather** = the mix of events (precipitation, humidity, temperature, etc.) that happen over a short period of time (minutes to months) in a specific location. For example, the temperature on June 12, 2012 for Durham, NH was 18.9°C.
- **Climate** = the long-term pattern of weather in a particular area. This is often measured as the average weather over a 30-year period (called a 'climate normal'). For example, over the past 30 years, the average annual temperature in Durham was 8°C.
- **Climate Normal** = an average of some climate variable over a 30-year period.

Materials:

- Computer with Excel and access to the Internet (One per student or student pair).
- Weather to Climate document
    - Structured Inquiry 1 (graphs included- *no computer needed*)- Temperature and Snow Depth versions.
    - Structured Inquiry 2 (students create graphs – *computer and Excel needed*)- Temperature and Snow Depth versions.
    - Open Inquiry (*computer with access to Internet and Excel needed. This option has students download data for a location of their choice and investigate a self-designed research question. Pages 1 and 2 of this worksheet could also be used for teachers to download and prepare a dataset for their students.*)
- Frayer Model worksheet
- Excel spreadsheets* (Structured Inquiry 2)
- Science notebook and pencil for recording questions, observations, and results (Open Inquiry)

Estimated Time: 1-3 hrs

What to Do and How to Do It: Structured Inquiry

1. INTRODUCTION Use the Frayer Model to initiate a discussion on the difference between weather and climate. Students can either create individual models or work in teams to come up with definitions. Have students share ideas with the class, and the teacher facilitates a discussion to clarify definitions. Briefly the Daymet dataset (Daymet uses computer software to extrapolate data from many weather stations to produce estimates of weather data over large regions. The data is available daily from 1980 to the present, and organized by ORNL DAAC- funded by NASA). Ask students why they think long-term records are

important. Remind students they will be using metric units (°C, mm); if necessary review the difference between Celsius and Fahrenheit.
2. Students, individually or in pairs, complete the *Weather to Climate Investigation*, using the data to answer questions. Students can choose to investigate either Temperature or Snow Depth at three possible locations (Durham NH, Boise ID, or Little Rock AR).
3. WRAP-UP: Students report out findings to class in a round robin discussion or on chart paper.

What to Do and How to Do It: Open Inquiry

1. INTRODUCTION Briefly discuss how to formulate a research topic and hypothesis, using the first page of the *Weather to Climate: Daymet handout* for topic suggestions. Optional: use the *Planning Guide for Scientific Research* and *The Science Notebook* Guide to help in the planning and research process (available from the Teacher Resources section of the Student Climate Data website). Describe the Daymet dataset (Daymet uses computer software to extrapolate data from many daily meteorological observations to produce estimates of weather data over large regions. The data is available daily from 1980 to the present, and organized by ORNL DAAC- funded by NASA).
2. Follow the instructions in the *Weather to Climate Investigation: Open Inquiry* document to download and prepare a dataset from Daymet.
3. Students spend 10-15 minutes exploring the data to help narrow their research question. Students record their research question in their science notebook.
4. Instructor supports the more open inquiry process by circulating among groups and encouraging students to pursue researchable questions (e.g., those that can be answered with the available resources and tools).
5. Use the *Weather to Climate Investigation: Open Inquiry* document for suggestions on how to begin analyzing the data.
6. Students record findings and observations in their Science Notebook.
7. WRAP-UP: Student groups share findings with classmates using chart paper to create a mini poster, or doing a brief presentation. For more ideas on communicating findings, see the GLOBE Carbon Cycle Communicating Findings and Results page.

Assessment:

1. Use the Teacher Version with example responses to assess the completeness of student's work.
2. Have students report out to the class on overall results/trends of their study.

** Data from Daymet. Thornton; P.E.; M.M. Thornton; B.W. Mayer; N. Wilhelmi; Y. Wei; R. Devarakonda; and R.B. Cook. 2014. Daymet: Daily Surface Weather Data on a 1-km Grid for North America; Version 2. Data set. Available on-line [http://daac.ornl.gov] from Oak Ridge National Laboratory Distributed Active Archive Center; Oak Ridge; Tennessee; USA. Date accessed: 2014/07/04. Temporal range: 1980/01/01-2013/12/31. http://dx.doi.org/10.3334/ORNLDAAC/1219*

Part 2. Global and Future Climate Data

Guiding Questions:

- Will the weather and climate patterns I observed in the local data continue into the future?
- How do local climate patterns compare to other regions of the world?

Definitions:

- **Global Climate Models** (GCM, aka General Circulation Models) = Evaluate the physical processes occurring throughout the Earth's 3-dimnesional land-ocean-atmosphere system. These models generate predictions extending 100 years into the future.
- **Emission Scenarios** = Characterize the heat-trapping gasses that we expect to find in the atmosphere based on different scenarios describing future trends in population growth, energy use, economic development, and technology use. For more information on models and emission scenarios, see descriptions from the World Meteorological Organization (http://www.wmo.int/pages/themes/climate/emission_scenarios.php).
- **Anomaly** = the departure from the average climate over a certain period. For example, a positive temperature anomaly indicates that the observed temperature was warmer than the average climate, while a negative temperature anomaly indicates that the observed temperature was cooler than the average climate.

Materials:

- Computers with access to the Internet (One per student or student pair).
- Science notebook for recording observations (Guided Inquiry only).
- *Climate Investigation* handout
    - *Structured and Guided Inquiry Options*

Estimated Time: 1 hour

What to Do and How to Do It:

1. INTRODUCTION As a hook, watch video(s) from the 'How Do We Know?' series on the Science 360 website- particularly, 'How Do We Know? The Warming of the Earth' ~1 min 20 sec). If your students have not studied climate change, use the Temperature Anomaly Animation to introduce the topic (see above definition of 'anomaly'). What trends do they notice? What areas might experience a greater temperature change?
2. Navigate to the Data Tools page. Instructor gives a brief tour of the tools that students will be using (Climate Maps, Animations, Single Site Climate Data tool).
3. In pairs, or individually, students follow the instructions on the *Climate Investigation* handout to explore climate change in their location of interest. The Structured experience directs students to specific data and provides data tables for recording trends. The Guided experience offers students options for data

collection, and an opportunity to design a means of recording trends in the science notebook.

4. (Optional) Complete the Extension part of the *Climate Investigation*, which asks students to compare their location to another location around the world by using Climate Comparison Google Motion Charts (**Note: this application needs java to run, and therefore will not work on an iPad).
5. WRAP-UP: Students share the results of their investigations with the class in either an informal or formal presentation. What questions do they still have? What would be the next step of their research?

Assessment:

1. Use the Teacher Version with example responses to assess the completeness of student's work.
2. Use the GLOBE Carbon Cycle Communicating Research Findings webpage (http://globecarboncycle.unh.edu/CommunicateFindings.shtml) for further resources and assessment ideas for student presentations, writing, and posters (guides, examples, sample rubrics, etc.).

** **What does a change in global temperature mean?** Students are often underwhelmed by the degree of temperature change predicted to occur in the next 100 years. To help them understand, here are some bullet points from the EPA. (http://www.epa.gov/climatechange/basics/facts.html)

"Changing the average global temperature by even a degree or two can lead to serious consequences around the globe. For about every 2°F of warming (only 1°C!), we can expect to see

- 5—15% reductions in the yields of crops as currently grown
- 3—10% increases in the amount of rain falling during the heaviest precipitation events, which can increase flooding risks
- 5—10% decreases in stream flow in some river basins, including the Arkansas and the Rio Grande
- 200%—400% increases in the area burned by wildfire in parts of the western United States

Global average temperatures have increased more than 1.4 degrees Fahrenheit over the last 100 years. Many of the extreme precipitation and heat events that we have seen in recent years are consistent with what we would expect given this amount of warming. Scientists project that Earth's average temperatures will rise between 2 and 12 degrees Fahrenheit by 2100."