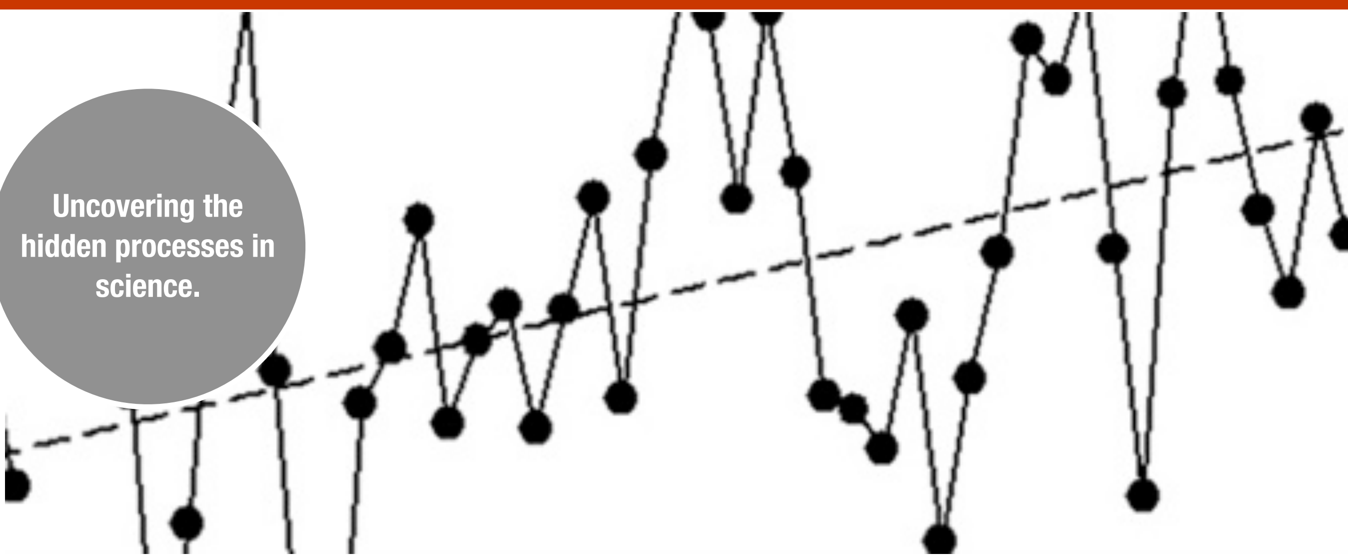
TIME SERIES

Long Term Research opens our eyes to the degree of an "invisible present"- a time-lapse of events that occur within one's lifetime. (Mangnuson,1990)

Uncovering the hidden processes in science.



Expand your perception of data

In the following exercise, you will review techniques useful to scientists as they analyze series of data. These sequences of measurements may or may not follow a pattern. Usually the data represent consecutive measurements taken at equal space/time intervals. In real life there is often considerable variability from year to year, so that long data records are needed to identify changes in ecosystems. Scientists need to not only uncover what hidden patterns are in their data but also attempt to generate forecasts.

The Invisible Present - a time where we may perceive the world as static, underestimating the degree of change that exists within our lifetime. Many natural processes often occur in broad contexts encompassing large ecosystems. What lies below the surface becomes visible when observed over long periods of time.

Objectives(s):

a. Identify the nature of the phenomenon represented by making a sequence of observations
b. Recognize a pattern or trend within the data
c. Predict future values of the data.
d. Understand the collaborative nature of science.

Time Frame: 45 minutes - 1 hour
Grade Level: 9 - 12

National Science Education Standards:

* Science as Inquiry: Abilities necessary to engage in scientific inquiry
* History & Nature of Science: Nature of scientific knowledge

Climate Literacy Principles:
Essential Principle 4 : Climate changes over space and time ...
- 4d Changes in climate are normal but vary over times/space.
Essential Principle 5 : Our understanding of the climate system is improved through observations...
- 5b Observations are the foundation for understanding the climate system

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Looking at Data

Teacher Instructions

> Note: At the start of this exercise students will only be analyzing snapshots of a 57-year time series to reinforce the nature and value of long term data sets.

1. Create working lab groups of 3 - 4 students.

2. Explain to the students that they will be analyzing monthly averaged surface air temperature in Antarctica.
   a. Use graph (A.) to approximate the average surface air temperature between 2001 - 2002.
   b. Can you convert that average to °F? Note: (°F = 9/5* Temp°C + 32)
   c. Ask the students to guess what the average surface air temperature might have been in the year 1999 - 2000 using graph (A) 1-year view.

3. Then have students discuss within their lab groups the answers to the following questions.
   a. What are the advantages/disadvantages of collecting data for one year?
   b. Can you predict a trend using only one year's worth of data?
   c. Hypothesize what the trend of surface air temperature might look like in the six years following 2001-2002 view in graph A.
   d. How might natural events, like increased precipitation (snow/rain) or increased temperature averages affect the Antarctic ecosystem?

4. Have all the working groups discuss their findings together as a class. Keep a log of student responses on an overhead or the board.

5. Take a moment to analyze the 10 - year (1999 - 2008) graph (B). Record your answers to the following questions:
   a. Was your prediction to the trend of surface air temperature correct? Explain what you see.
   b. Is their evidence of a trend now that you can see 10 years worth of data?
   c. Is there great variability in the climate over the course of ten years?
   d. Speculate what the surface air temperature was prior to 1999 using graph B.
   e. What is the advantage of having a data set of this extent that collects a 57-year data record?

6. Discuss these answers together with the entire class and record student answers on the board or the overhead.

7. Share what you have learned. If time permits, reveal the entire 57-year record. Discuss the trend and the possible influences of this trend on the Antarctic Ecosystem.

Surface Air Temperature

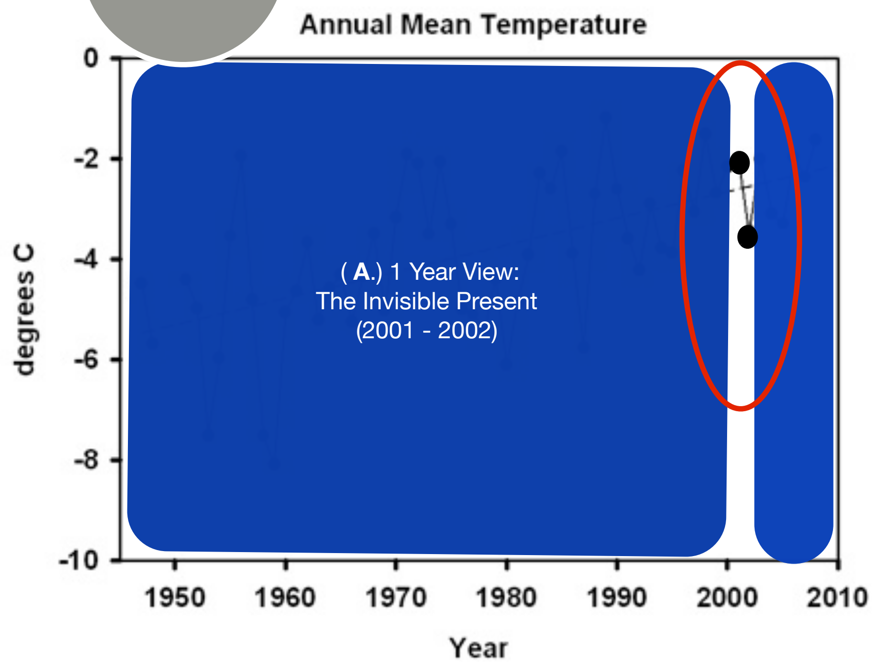
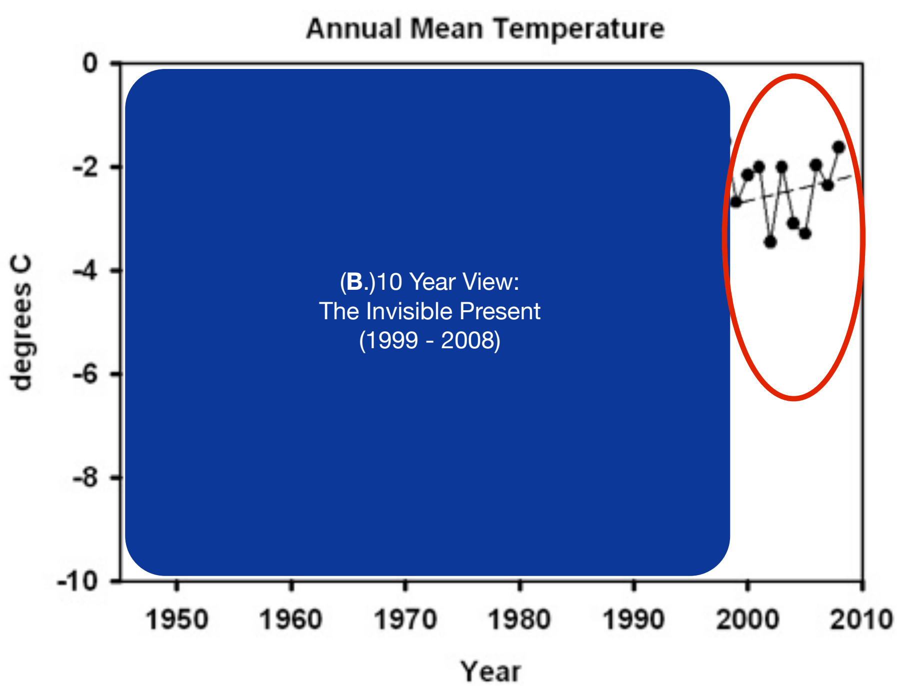


Figure 1(A,B): Annual average surface air temperature recorded at Faraday/Vernadsky Station (65°15'S, 64°16'W) from 1951 to 2008. The linear regression fit (solid)and ± standards deviation (dotted).



Student Worksheet A

Name:___________________________

Date: ___________________________

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Note: In the beginning of this
exercise you will only be analyzing
snapshots of a 57-year time series.
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Question: Analyze the monthly average surface air temperature in Antarctica using graph (A).

a. Approximate the average surface air temperature in 2001 - 2002. Use Graph (A).

b. Convert that average to °F = __________
   Note: °F = 9/5*Temp°C + 32

c. Guess what the average surface air temperature might have been leading up to this year.

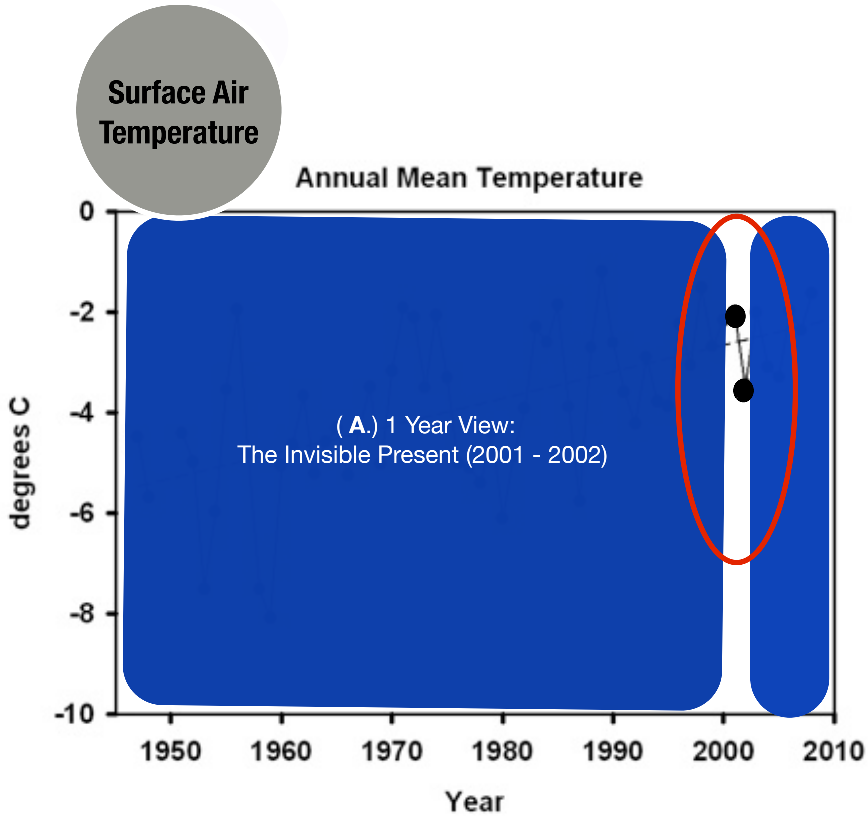

Figure 1(A,B): Annual average surface air temperature recorded at Faraday/Vernadsky Station (65°15'S, 64°16'W) from 1951 to 2008. The linear regression fit (solid)and ± standards deviation (dotted)

Discuss the following questions with your lab group.

a. List the advantages/disadvantages of collecting data for one year?

b. Can you predict a trend using only one year's worth of data? Explain.

c. What predictions can be made about the air surface temperature in the 6 years that follow in graph A.

d. How might natural events, like increased precipitation (snow/rain) or increased temperature averages affect the Antarctic ecosystem?

e. Share your small lab group discussions with the entire class and log responses on the overhead of board.

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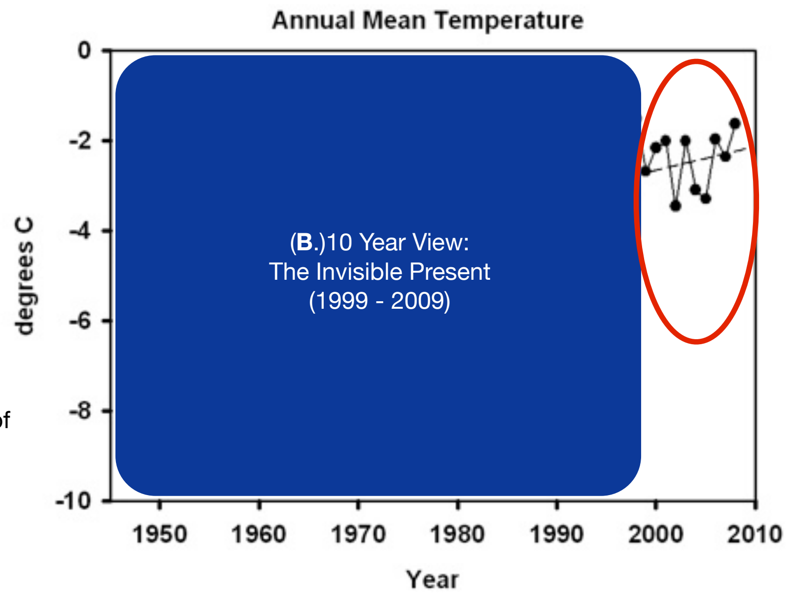
Student Worksheet B

Name:______________________

Directions: Take a moment to analyze the 10 - year graph (B) and record your answers to the following questions.



a. Was your prediction correct about the air surface temperature in the 6 years that follow 2001-2002?

b. Now that you see 10 - years worth of data, is their evidence of a trend?

c. Is there great variability in the climate over the course of ten years?

d. Speculate what the surface air temperature might have been in the years prior to 1999 on graph B.

e. What is the advantage of having a 57- year data record?

Share and discuss as a class the value of a long term data set.

If time permits, your teacher will reveal the entire 57-year record. The evidence is clear as to what the trend is doing over time. Discuss the possible influences of this trend on the Antarctic Ecosystem.

AIR TEMPERATURE

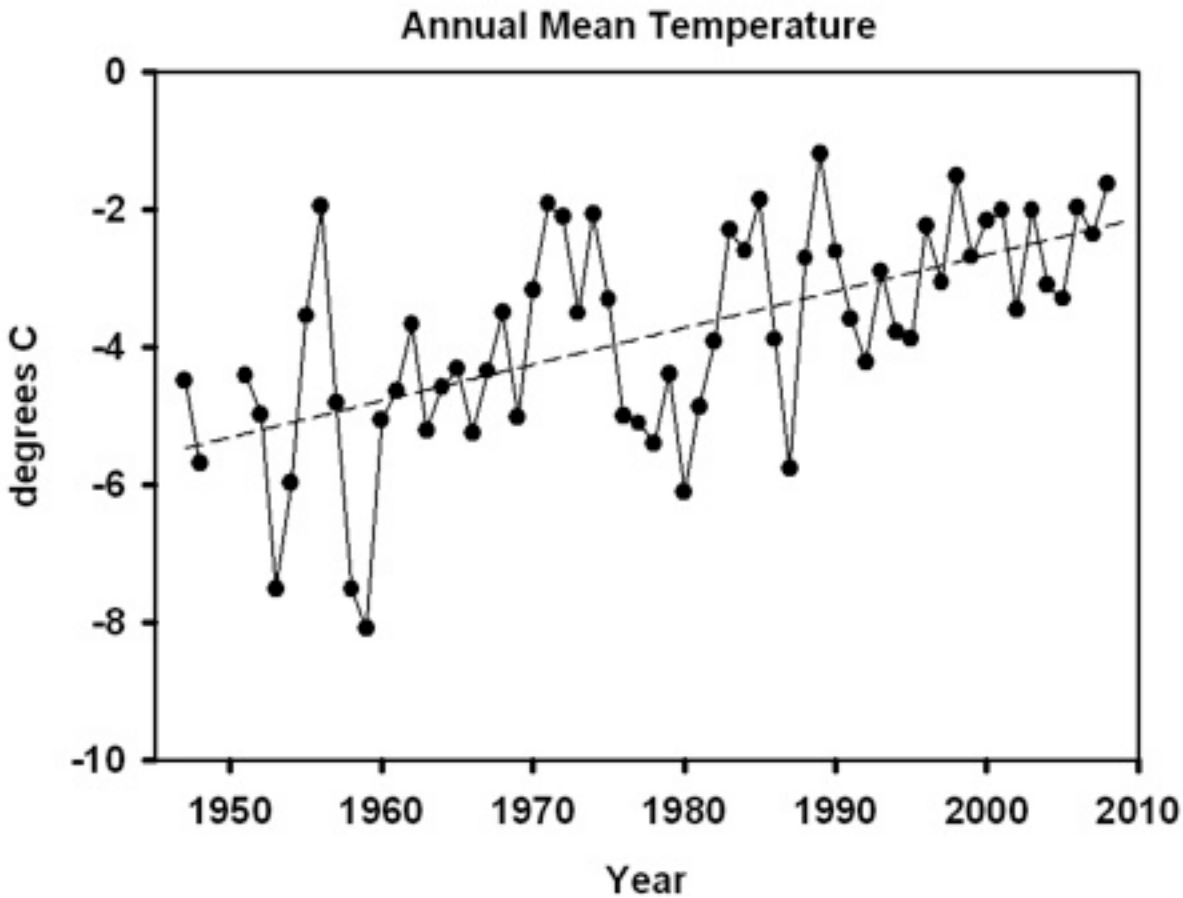


Figure 1 (A,B) : Annual average air temperature recorded at Faraday/Vernadsky Station (65°15'S, 64°16'W) from 1951 to 2008. The linear regression fit (solid)and ± standards deviation (dotted).

Background Understanding:
Understanding the invisible present requires making observations over long time scales. When a time series opens up like the fifty-seven year record in this exercise, it makes the present information in our lifetime more understandable giving the entire story more context over a longer time frame. We can see now that recent changes in surface air temperature are part of a much longer warming trend. This demonstrates that the natural world is dynamic and complex and changing all the time. This emphasizes the importance of sustaining ecological research and encourages collaboration by scientists at institutions all over the world. Researchers like those from Palmer Long Term Ecological Research (LTER) program concentrate their efforts on unveiling the invisible present. The research helps us synchronize our perceptions with scientific findings ultimately shaping our understanding of global issues.

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Teacher Answer Key A

Question: Analyze the monthly average surface air temperature in Antarctica using graph (A).

a. Using graph A. approximate the average surface air temperature for the two years 2001-2002?
The average surface air temperature in 2001-2002 was approximately -3˚C

b. Convert your answer to °F = 26.6˚F
Note: °F = 9/5*Temp°C + 32

c. Guess what the average surface air temperature might have been in the year leading up to 2001. Use graph (A) 1 - year view. Student answers will vary.

Discuss the following questions with your lab group.

a. List the advantages/disadvantages of collecting data for one year?
Collecting data on any event for a single year is relatively uninteresting in that it provides no insight into the long - term behavior or changes of a natural system. Many processes in the natural world simply take time. However, when a 10 or 50 plus year record is obtained, new phenomena are exposed allowing the invisible present to be put into context and the ecosystem to be better understood.

b. Can you predict a trend using only one year's worth of data? Explain. No.

c. What predictions can be made about the surface air temperature in the 6 years that follow 2002 in graph A. Student answers will vary.

d. How might natural events, like increased precipitation (snow/rain) or increased temperature averages affect the Antarctic ecosystem? The answers to this question may vary based on what existing knowledge the students have on the Antarctic ecosystem. If a late-spring snowfall and rain increase in the area it may be resulting from a warming climate which can bury nests and drown eggs and chicks, leading to increased bird mortality in penguins. It can also result in less sea ice formation which affects all levels of the food chain. For example, some diatoms (small phytoplankton) are currently being replaced by cryptophytes (small phytoplankton lacking shells). Krill which are crustaceans that resemble shrimp are highly depended on sea ice without which they cannot complete their life cycles and breed as successfully. So, natural events like increased precipitation or increased temperature averages affect the Antarctic ecosystem across many levels.

e. Share your small lab group discussions with the entire class and log responses on the overhead of board.

Teacher Answer Key B

Directions: Take a moment to analyze the 10 - year graph (B) and record your answers to the following questions.

a. Was your prediction correct about the air surface temperature in the 6 years that follow 2002?
Student answers will vary.

b. Now that you see 10 - years worth of data is there evidence of a trend? Yes, the surface air temperatures are increasing over time.

c. Is there great variability in the climate over the course of ten years? Yes, from year to year there is great variability (range of change). The linear regression fit line (solid line) on the graph helps you visualize an increase in the annual average surface air temperatures recorded at the Faraday/Vernadsky Station all the way down to Rothera Station. Climate varies at all time scales, from months to millions of years and longer. Scientists study these variations to see how climate is linked across time scales. These types of observations help scientists to predict future changes in climate and aid in a better understanding of ecological processes.

d. Speculate what the surface air temperature might have been in the years prior to 1999 on graph B. Student answers will vary.

e. What is the advantage of having a 57- year data record? A fifty-seven year record like this unveils the invisible present, showing the progressive, long-term changes in the ecosystem that are not detectable after only 1 or a few years' measurements.

Share and discuss as a class the value of a long term data set.

Assessment: If time permits, we highly recommend that you reveal the entire 57-year record. The evidence is clear as to what the trend is doing over time and would be a valuable visualization for the students to see. Discussing or having the students write an essay about the possible influences of this trend on the Antarctic Ecosystem would be supported by students reading: Ducklow et al. (2007) Marine Pelagic Ecosystems: the Western Antarctic Peninsula. The Royal Society paper - Philosophical Transactions of The Royal Society B (2007) 362, 67-94. (Found: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1764834/)

Teacher Notes:

This activity is best suited to introduce students to learning strategies used in analyzing data in inquiry-based science lessons. A series of questions guide students through the activity arousing their curiosity promoting critical thinking skills surrounding the Palmer LTER time series. This activity should be completed cooperatively by students or in smaller groups. Whole group or classroom discussions based on the entire time series will aid students visualizing the entire 57-year record. Links are shared below relating to other climate related data at Palmer station, Antarctica. The data can be utilized in multiple ways to check for understanding or reinforce skills or engage students further in analyzing data.

Reference:

Manguson, John J. (1990) Long-Term Ecological Research and the Invisible Present: Uncovering the processes hidden because they occur slowly or because effects lag years behind causes. BioScience Vol. 40 No. 7. Pgs. 495 - 501. http://limnology.wisc.edu/personnel/magnuson/articles/magnuson_biosci_v40-7-495.pdf

Ducklow et al. (2007) Marine Pelagic Ecosystems: the Wester Antarctic Peninsula. The Royal Society paper - Philosophical Transactions of The Royal Society B (2007) 362, 67-94. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1764834/

Resources:

McClintock, James, Ducklow, Hugh & Fraser William (2008) Ecological Responses to Climate Change on the Antarctic Peninsula. American Scientist, Vol. 96. Pgs. 302 - 310. http://www.americanscientist.org/issues/pub/2008/4/ecological-responses-to-climate-change-on-the-antarctic-peninsula/1

Signature Data Set: Download Palmer Station LTERs twenty-three year weather data set from (1989 - 2012) in Excel.: http://pal.lternet.edu/data/.