Using the SMBO to Examine Vertical Temperature Structure

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Grade: 9 - 12
Group Size: various
Time: 2+ hours in computer lab.

BACKGROUND

— The UCLA SMBO, Santa Monica Bay Observatory, is an instrument-packed buoy moored at the outer edge of Santa Monica Bay (33º 56' N, 118º 43' W). The mooringprovides a real time data stream and historical archives via the Web: http://quercus.igpp.ucla.edu/smbo/smbo_mooring.html, or http://www.ioe.ucla.edu/mucla/ . Data sets include: air temperature, wind speed, wind direction, conductivity, temperature, pressure sensors down to 100 m water depth, transmissometer and fluorometer at approximately 0.5 m water depth, downward looking Acoustic Doppler Current Profiler (ADCP) at about 2 m water depth, and Air-sea partial pressure of CO_2 and oxygen difference analyzer (not continuous).

—The vertical temperature structure of the ocean typically includes 3 layers: a surface layer, a layer of temperature decline within a small depth range (also known as the thermocline), and a deep, bottom layer. The nature of the vertical temperature profile changes with latitude and season. In the Santa Monica Bay, the profile is characterized during the summer by a warm surface layer, a sharp thermocline, and a cold bottom layer. On the other hand, in the winter, the surface layer is not so warm and the layers tend to be mixed by storms, so the thermocline is not as distinct. Of course, these are very broad, general descriptions and the month-to-month, week-to-week and even day-by-day changes in thermal structure are fascinating.

—Instructors should be familiar with the contents of the "Ocean Temperature" PowerPoint slideshow before using it to prepare your students for this computer lab exercise: http://www.msc.ucla.edu/oceanglobe/ppt/enviromentalNotes/index.htm

OVERVIEW

In this lesson students will do two things:

1- Describe the UCLA SMBO, characterize its data, and use the SMBO web interface to explore both real time and historical data sets.

2- Use the historical data to capture and compare vertical temperature profiles for each of the four seasons.

CONTENT STANDARDS – Grades 9 - 12

Investigation & Experimentation

Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop their own questions and perform investigations. Students will:

— Select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.

— Formulate explanations by using logic and evidence.

— Analyze the locations, sequences, or time intervals that are characteristic of natural phenomena (e.g., relative ages of rocks, locations of planets over time, and succession of species in an ecosystem).

— Recognize the issues of statistical variability and the need for controlled tests.

— Recognize the cumulative nature of scientific evidence.

— Analyze situations and solve problems that require combining and applying concepts from more than one area of science.

Earth Sciences

Heating of Earth's surface and atmosphere by the sun drives convection within the atmosphere and oceans, producing winds and ocean currents. As a basis for understanding this concept:

— *Students know* properties of ocean water, such as temperature and salinity, can be used to explain the layered structure of the oceans, the generation of horizontal and vertical ocean currents, and the geographic distribution of marine organisms.

PERFORMANCE OBJECTIVES

Given access to an online computer and printer, students will…

1- produce a 1-page illustrated document or a 5 slide PowerPoint series, with an introduction to the SMBO buoy including at least one "fascinating fact" learned from exploring the online data.

2- prepare a multi-page report document or multi-slide PowerPoint series which includes at least one graphic plot of temperature vs depth for each season, a short discussion of the meaning of each graph, and a summary comparison of the temperature profiles through the seasons.

MATERIALS

Computer, software, internet connection
Printer
Paper

ADVANCE PREPARATION

1- Students should understand the general distribution of heat in the ocean by observing and taking notes using the UCLA OceanGLOBE Ocean Temperature PowerPoint presentation.

2- Students should know where to go on the Web, and what to do on the SMBO web site, in order to access real time and historical data.

PROCEDURE

1. Inquiry Question:

What happens to the ocean temperature as you dive down into Santa Monica Bay?

2. Hypothesis:

Based on your knowledge of ocean temperatures, formulate a hypothesis about the vertical temperature structure of Santa Monica Bay during the summer, fall, winter and spring seasons.

3. Procedure:

Here are the steps you should follow:

a. Go to: http://quercus.igpp.ucla.edu:8080/las/servlets/dataset
b. Click on "Santa Monica Bay Mooring (TSS: 2001-2003 deployment)"
TSS stands for Temperature-Salinity String. This is the data collected from the microcats going down to 100m.
c. Check off the box for "TSS temperature (interpolated)." Next>
d. Select View: Depth Profile
Select Output: Line Plot
Select Region: Full Region
e. One plot at a time, select various days of the year that reflect the seasons and seasonal changes in temperature. Next>
f. Right click your mouse on each important graph. Choose "Copy" or "Save As" for later use in this project..

4. Data and Observations

Find, copy and save one summer profile, one fall profile, one winter profile and one spring profile. Paste them into your piece of work (document file or PowerPoint show).

5. Conclusion

a. Summarize what each seasonal graph tells you. Use real numbers in your summer.
b. What differences are there between the surface temperatures during each of the four seasons?
c. How does the thermocline layer change during each season?
d. Describe the differences you can see between deep water temperatures during each season.
e. Propose a list of the environmental factors for each season that might account for the temperature patterns you observed.

EXTENSIONS

Explore temperature changes within a

1- day
2- week
3- month
4- compare one year to the next
5- find and compare data from other geographic locations
6- find and explore data regarding thermoclines from the past

RESOURCES

A great introduction to the effects of thermoclines on living things:
The Seasonal Thermocline and Its Effect on Phytoplankton. http://www.oceansonline.com/thermocline.htm

A downloadable academic journal article for advanced students that love math and physics:
Cessi, Paola and M Fantini, The eddy-driven thermocline. Journal of Physical Oceanography. 34 (12), pp. 2642-2658. (2004). Postprint available free at: http://repositories.cdlib.org/postprints/591

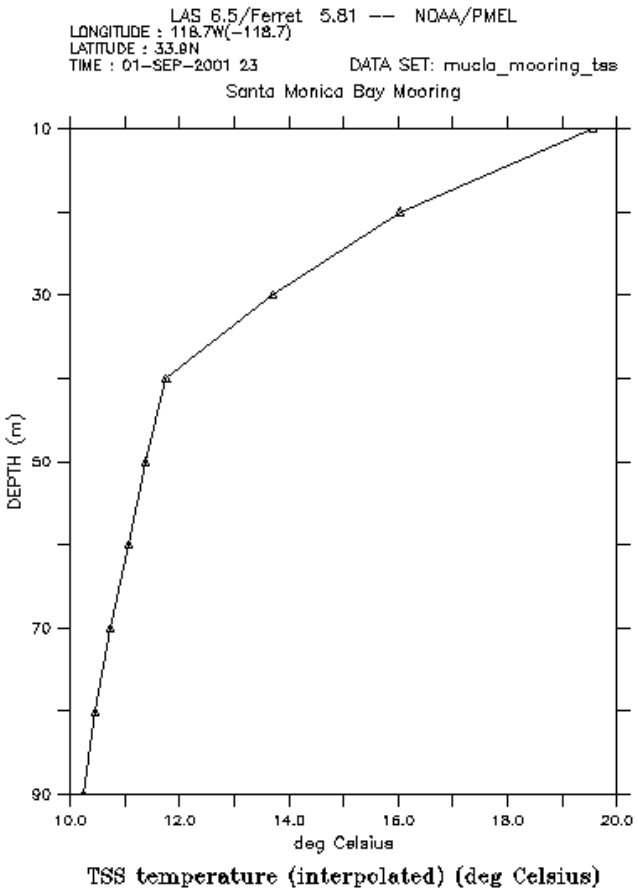
A classic piece of literature:
Munk, Walter H., and Ernest R. Anderson, Notes on a theory of the thermocline. Journal of Marine Research, Vol 7, No 3, p 276-295, November 1948.

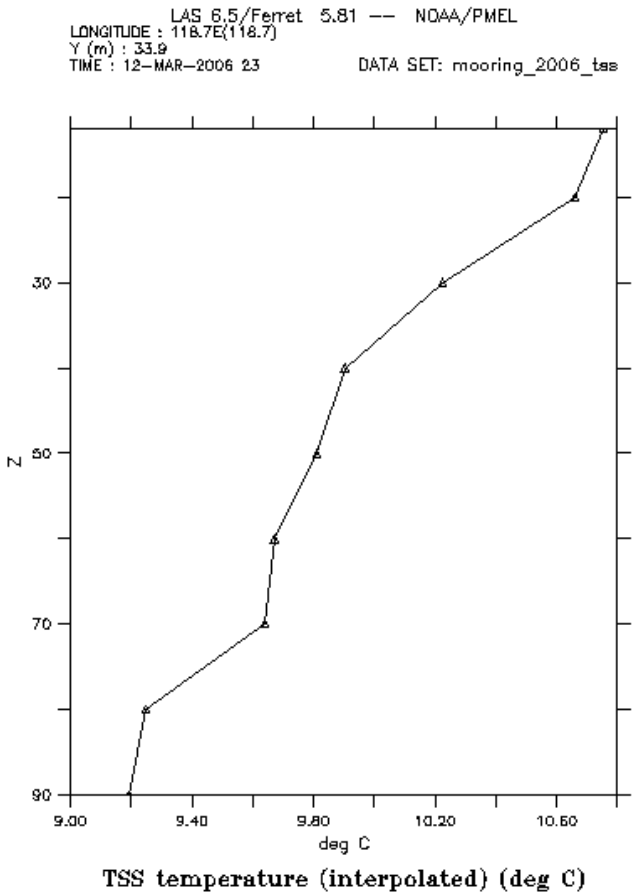
A variety of journal articles for a wider view of thermoclines:
Andreasen, D.J. and A.C. Ravelo, Tropical Pacific Ocean thermocline depth reconstructions for the last glacial maximum. PALEOCEANOGRAPHY, 1997.

Xie, Shang-Ping, Tatsuga Kunitani, Atsushi Kubokawa, Masami Nonaka, Shigeki Hosoda, Interdecadal Thermocline Variability in the North Pacific for 1958–97: A GCM Simulation. Journal of Physical Oceanography: Vol. 30, No. 11, pp. 2798–2813.

Ffield, Amy and Arnold L. Gordon, Vertical Mixing in the Indonesian Thermocline. Journal of Physical Oceanography: Vol. 22, No. 2, pp. 184–195.

Appendix A - Sample data plots retrieved from the SMBO web site.





The graph on the left shows a summer profile, the right a winter profile. Caution students to look carefully at the temperature scale range on their downloads prior to forming hypotheses.