# J2.3 USING DIGITAL LIBRARIES TO TEACH OCEANOGRAPHY

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## 1. INTRODUCTION

I have almost totally stopped using printed texts in courses I teach. The courses include college-level physical oceanography for meteorologists, oceanographers, and ocean engineers, introduction to environmental geosciences for students of all interests, and a graduate course in physical oceanography.

## 2. WHY NO TEXTBOOKS?

For many reasons, traditional textbooks are not ideal for teaching the geosciences.

1) Textbooks are often out of date by the time they are printed. The geosciences are changing rapidly. Today's knowledge of El Nino, global warming, or the deep circulation in the ocean differs from our knowledge two years ago when the most up-to-date textbooks were written. Many books, especially at the graduate level, were written far more than two years ago.
2) Textbooks cover far too many topics. And topics that are naturally related are not tied together.
3) Textbooks are organized around processes, not around important problems. Students want to know about fisheries, or global warming, not Ekman currents or transfer of radiation in the atmosphere.
4) Textbooks are expensive. Introductory oceanography books cost $90 ± 10, with some costing more than $100. Specialized texts tend to be even more expensive.

## 3. WHAT REPLACES TEXTBOOKS?

Many professors solve the textbook problem by using course packets of selected reading. But this solution also introduces outdated material if the readings come from printed texts other than recent journals and magazines. And making multiple copies of texts is expensive.

I solve the problem in a simpler way. I ask my students to read selected materials from the web, and I ask them to use on-line data sets for homework assignments. I also use on-line textbooks.

I have found excellent material on many subjects, including short articles, tutorials, and textbooks, most of which were written by experts. For example, when I teach global warming, I can refer to the entire Intergovernmental Panel on Climate Change Third Assessment Report is available on line, including: *Climate Change 2001: The Scientific Basis*; *Impacts, Adaptation, and Vulnerability*; *Mitigation*; and *Synthesis Report*. Many authors have begun to publish their textbooks online. Other authors have written excellent tutorials for their own students and placed the material on the web for all to use.

Today the web has become a digital library—vast, deep, and diverse. Most material is well indexed through commercial search engines such as Goggle. More is being indexed and cataloged in the Digital Library for Earth System Education DLESE and other gateways.

## 4. AN EXAMPLE

Here is an example of how I use the web as a digital library:

I teach a problems-based, general oceanography course for upper-division students, many of whom plan to be teachers. The course is organized around important oceanic problems:

1) Global warming and the ocean's role in climate;
2) El Nino and changing weather patterns;
3) Pollution in coastal regions;
4) Fisheries and overfishing; and
5) Coastal erosion.

I teach the course using material exclusively from online digital sources. Although much of the material is not yet in a a digital library, it is typical of the material that is being cataloged by the Digital Library for Earth System Education and the Gateway to Educational material GEM. My experiences, and the structure of the course are applicable to most geoscience courses.

Students use on-line digital material to learn about the problems, to obtain scientific information necessary to understand the problem, and to access data necessary to describe processes. There is no textbook.

Consider the first topic: global warming. There are excellent on-line tutorials describing the different types of greenhouse gases, their sources and sinks, and their influence on global surface temperature. The body of the IPCC reports tend to be too technical for undergraduates, so I use the executive summaries from the reports, on-line tutorials produced by the U.S. Environmental Protection Agency, the Department of Energy's Atmospheric Radiation Measurement Program, and the US Global Change Research Information Office.

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Online data sets have information necessary to describe warming in various regions, the concentration of greenhouse gases in the atmosphere, and the production of greenhouse gases.

Most of the information is up-to-date, complete, and well written. Furthermore, students can explore possible solutions to the problem, and the implications for society, topics usually not covered in texts. Thus, they can read the text of the Kyoto Agreement, subsequent UNESCO documents, and commentary on the Kyoto protocol by interested parties, including the U.S. Congressional Research Service.

Homework assignments often make use of web-based material. For example, the one homework question for the coastal erosion module asks:

Look at this satellite photograph of Cape Hattaras.

- Is there a offshore bar north of the cape?
- What evidence have you used to answer the question?

The photograph comes from a wonderful collection of coastal photographs assembled by the Science Junction center at North Carolina State University. The photos are in the Carolina Coastal Science for teachers.

Science Junction is an example of a web resource that combines interesting scientific problems with data useful for teaching science related to the problem. Their web site states:

*Science Junction is a center for teaching, learning, and integrating science into our daily lives. This is an interactive site seeking to make connections between the researchers and educators at north carolina State University and the teachers, children, and parents of North carolina. The Science Junction promotes inquiry and provides resources to promote the NC Standard Course of Study and national teaching standards.*

## 5. STUDENT FEEDBACK

Students taking the course like the organization around scientific and societal problems, the ability to read about important problems from several perspectives, the ability to get up-to-date information, and the ability to access additional selected information quickly through the web.

Perhaps 5% tend to be concerned that they don't have a conventional text, although they are glad to avoid the high cost of typical oceanographic texts. To alleviate these students concerns, I recommend common textbooks they can use to supplement what we discuss in class.

A few percent have problems with slow web access. They are mostly students who live in rural areas. Most student near campus have fast web access through cable modems. Slow web access can be solved by students downloading and saving material in digital form while they are on campus where there are fast internet connections.

Overall student evaluations of the course are very positive.

## 6. DATA SITES

More advanced classes benefit from access to good geophysical data. I find the most useful sites:

1) Provide access to many different, related data sets. This allows students to compare the maps of the same variable compiled from different sources, or to see correlations between different variables.
2) Feature large maps, in gif or jpeg format, showing most of the features I want students to understand. I rarely need to refer students to ftp sites for digital data used to make the maps. Little maps are of little use.
3) Hold the same data fields from many different dates, especially daily, monthly, or yearly time series. We often need to see daily, monthly, and yearly changes in the ocean.

Remote Sensing Systems operates a very useful site that meets these criteria. The have:

1) Daily, weekly, and monthly images from the:
2) Special Sensor Microwave/Imager SSM/I on the Defense Meteorological Satellite Program satellites; the TRMM Microwave Imager TMI on the Tropical Rainfall Measuring Satellite TRMM, and the scatterometer on Quikscat;
3) Showing sea-surface winds, atmospheric water vapor, cloud liquid water, and rain rate from SSM/I from 1987 to 2002.
   Sea-surface temperature, atmospheric water vapor, surface wind speed, cloud liquid water, and precipitation rate from TMI 1997 to 2002; and
   Surface wind speed and direction from Quikscat from 1999 to 2002.
4) Clicking on an image opens a window with a much larger, 1560 by 1090 pixel or similar global image .

Using this site, students can quickly and easily study the interrelationships among these variables.

Other similar sites are operated by:

1) International Research Institute for Climate Prediction. In their data library they have perhaps hundreds data sources (I had no way of cataloging all the data sets, but they are extensive), including time series maps, and mean maps of variables. All maps can be produced at the same size and resolution.
2) The NOAA National Climate Data Center's Live Access to Climate Data is another data gateway providing access to 21 data sets.
3) The NOAA National Virtual Oceanographic Data System at the Pacific marine Environmental Laboratory provides access to dozens of oceanographic data sets held locally and in many

other servers at many other institutions.

4) The French Coriolis data center provides access to hundreds of drifters being deployed by Argo and the Global Ocean Data Assimilation Experiment.
5) FishBase provides detailed information on 26,870 species of fish.
6) I have found that the NASA sites are more oriented toward the research scientist. They have fewer resources useful for students. The Goddard Space Flight Center's Earth Sciences Distributed Data Archive has many maps of ocean color.
7) NASA's Earth Observatory provides access to many time series of maps. I have tended not to use these maps because they are so small, 360 by 180 pixels, one pixel per degree.

## 7. DISCUSSION

I have spent many hundreds of hours searching the web for useful material. I find the large search engines such as Google, or Sherlock for the Mac, are more useful than education gateways or digital libraries. Google tends to give me a wider variety of useful links and a wide variety of viewpoints. DLESE gives me links more tailored to the classroom but more removed from the original scientist. Using global warming again as an example, Sherlock gives me sites ranging from Greenpeace to the American Petroleum Institute. DLESE gives me Greenpeace but no industrial perspective.

Digital maps of important variables, such as rain rate or temperature, tend to be distributed over many sites operated by different projects, and with different interfaces. I hope more organizations follow the lead of NOAA or the International Research Institute in producing "live access servers" that distribute a wide variety of data sets through a common interface and in a common format with sufficient detail that they can be used in the classroom.

Often I must read through several paragraphs to determine the target audience for the material. Why not a simple statement on the home page stating the technical level of material, especially material for students?

Finally, web pages, even very good web pages keep changing their address without providing a forwarding address. Imagine all your friends moving every few years without telling you, expecting you to find them somehow. Do we need web archives? Or forwarding addresses that last long enough for web search engines to find the new site.

## 8. CONCLUSIONS

In my opinion, introductory science courses can now be taught better using only digital libraries. The World-Wide Web provides access to quality, up-to-date information, tutorials, textbooks, historical data sets, real time data sets, and time series of data and mapped data.

Although I teach at the college level, the same approach has been used successfully at the high-school level.

## 8. REFERENCES—WEB SITES


**Carolina Coastal Science:** http://www.ncsu.edu/sciencejunction/terminal/lessons/coast/index.html

**Coriolis Data Center:** http://www.coriolis.eu.org/coriolis/cdc/

**Courses: General Oceanography:** http://oceanworld.tamu.edu/ocean401/

**Courses: Introduction to Physical Oceanography:** http://oceanworld.tamu.edu/ocean410/

**Courses: Introduction to Environmental Geoscience:** http://oceanworld.tamu.edu/geos105/

**Department of Energy: Global warming site** http://www.arm.gov/docs/education/warming.html

**Environmental Protection Agency: Global warming site** http://www.epa.gov/globalwarming/

**FishBase:** http://www.FishBase.org/home.htm

**Gateway to Educational material:** http://www.thegateway.org/

**International Research Institute for Climate Prediction:** http://iridl.ldeo.columbia.edu/

**Kyoto Protocol:** http://unfccc.int/resource/docs/convkp/kpeng.html

**NASA Earth Observatory:** http://earthobservatory.nasa.gov/

**NASA Goddard Space Flight Center's Earth Science Distributed Active Archive Center:** http://daac.gsfc.nasa.gov/oceancolor/

**NOAA: Live Access to Climate data:** http://www.ncdc.noaa.gov/cgi-bin/otter/v3.1/LAS

**NOAA Virtual Oceanographic Data System:** http://www.ferret.noaa.gov/nopp/main.pl?

**North Carolina State University Science Junction:** http://www.ncsu.edu/sciencejunction/

**Remote Sensing Systems:** http://www.remss.com/

**Science Junction:** http://www.ncsu.edu/ sciencejunction/ about.html

**US Congressional Research Service Global Warming Reports:** http://cnie.org/NLE/CRSreports/Climate/

**US Global Change Research Information Office** http://gcrio.ciesin.org/index.shtml

**United Nations Framework Convention on Cli-**

**mate Change:**
http://unfccc.int/index.html
**United nations IPCC Reports:**
http://www.ipcc.ch/