P1.19 THE USE OF NEAR REAL-TIME DATA FOR RESEARCH AND TEACHING AT AN HISPANIC SERVING INSTITUTION: LEVELING THE PLAYING FIELD

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1. INTRODUCTION

Colorado State University–Pueblo (CSU–Pueblo), is a regional comprehensive university, federally designated as an Hispanic Serving Institution. Although part of the greater Colorado State University system, CSU-Pueblo is a teaching-intensive institution and is relatively resource-poor. It serves a largely working class population (US Census 2000). As such, CSU-Pueblo students have not had access to the type of research equipment, data and field locations traditionally associated with larger, well-funded research programs.

Fortunately, the advent of easily accessible, networked measurements of the physical world via the Internet is rapidly changing this scenario. It is now possible to supplement on-campus resources with online images and near real-time data. This paper presents two examples of how authentic observation tools and research experiences can be integrated into standard course offerings.

2. BACKGROUND

A culturally and ethnically diverse "steel town" of approximately 100,000, Pueblo is located along the Front Range of the Rocky Mountains. Geographically, historically and culturally allied with northern New Mexico, the Arkansas River in Pueblo has served over the years as the border between the United States and Spain, then France, and Mexico. CSU-Pueblo draws primarily from this local population, serving roughly 4,000 students with its twenty seven undergraduate programs and five masters programs.

Like other minority serving institutions, CSU-Pueblo educates a large proportion of the Latinos in the region. Despite its small size, in 2006 CSU-Pueblo graduated more "Hispanic" students in the STEM disciplines (science, technology, engineering and mathematics) than any other public institution in the state of Colorado (e.g., Hispanic STEM graduates to total STEM graduates for CSU-Pueblo = 35/163; CU-Boulder = 29/1,202; CSU Fort Collins = 21/1,144; UCCS = 19/348) (Human 2007).

CSU-Pueblo also makes a contribution to the pool of underrepresented minorities who go on to achieve doctoral degrees in the sciences. In the ten year period between 1996 and 2005 fourteen such graduates received PhDs in STEM disciplines (NSF 2007). CSU-Pueblo's science and non-science majors alike, from both underrepresented minority and majority groups can clearly benefit from the additional training available through new technologies. Internet resources providing time-lapse images and continuous *in situ* measurement of environmental variables are particularly valuable. Two different courses, Oceanography Laboratory (Geology 114L) and Ecology Field Studies (Biology 453L) are discussed as examples of how such authentic data can be used to augment teaching and research activities.

3. COURSE DEVELOPMENT

One of the courses that incorporates online data is a newly instituted oceanography course at CSU-Pueblo. Prior to the mid-1980s CSU Pueblo (under its previous name of University of Southern Colorado) had a well-known geology department, but downsizing forced this program to close. New technologies make it possible to develop and re-introduce a course like oceanography, which has not been offered in years.

Prior to developing the oceanography course, the author attended the American Meteorological Society's (AMS) Online Ocean Studies faculty workshop in June 2007 in Seattle, Washington. While the AMS curriculum is designed to be offered by both experienced and novice instructors, this author also had previous training in ocean sciences (holding a bachelor's degree in biological oceanography and a doctorate in aquatic ecology), which was helpful in the design, approval and implementation phases of the course.

3.1 Challenges

The major impediments in implementing the course were: 1) fitting the new course into existing course offerings; 2) gaining university approval to add a new course; and 3) acquiring sufficient knowledge about the course format to allow for ease in course design and delivery.

The first issue was addressed at the departmental level where a decision was made to replace one of CSU-Pueblo's offerings of an earth science course (taught four times a year) with an offering of oceanography. The second issue involved submitting a formal request to the Curriculum and Academics Program Board at CSU-Pueblo. The addition of Oceanography (Geology 114/L) to the university's offerings was approved in Fall 2007. The issue of design and implementation are being addressed with the help of information disseminated at the faculty workshop. The ability to access both archived and current course materials online has been key in helping to prepare for the course.

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3.2 Progress to date

The approval and implementation processes were helped by the fact that oceanography had once been offered at CSU-Pueblo. The fact that the author was on sabbatical leave during the approval period helped as well, since the course is not slated to be offered until Spring 2009.

It is anticipated that the extra lead time should allow sufficient time for the submission of the paperwork needed to qualify oceanography as a general education natural and physical sciences elective (as earth science currently is). We anticipate that the oceanography course will become a popular option for both non-science majors and for science majors with an interest in this topic area. Response to an article published in the local newspaper (Perez 2007) suggests that this will be the case.

4. INCORPORATION OF ONLINE DATA

The author first became involved in discussion of the educational application of online and near real-time data when she served as a Higher Education Committee member of the National Ecological Observatory Network Design Consortium (2004-2005). Interest in this mechanism of data acquisition and use led to her participation in the AMS Online Oceans Faculty Workshop. The author furthered her knowledge of online data resources by attending a CENS-sponsored class at the James Reserve titled "Sensing Technology for the Soil Environment."

From participation in these activities it became clear that the Internet could be an effective means of accessing authentic current, archived and near real-time data sets. These can, in turn, be used for teaching and research purposes.

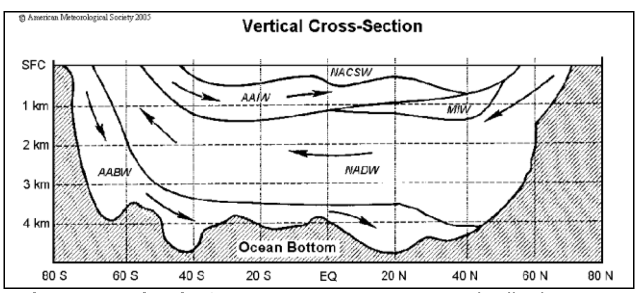

Figure 1. Atlantic Ocean Water Masses. Longitudinal cross section of the Atlantic Basin showing stratification and movement of water identified by temperature and salinity. Note Mediterranean Intermediate Water (MIW) intrusion from the Mediterranean Sea (Ch. 6B, Fig. 4; AMS 2007).

4.1 Online Ocean Studies

The American Meteorological Society's introductory college-level Online Ocean Studies course offers numerous opportunities to incorporate near real-time data into coursework (AMS 2007). The *Online Oceans Studies Investigation Manual* that is part of this course is updated each year to keep abreast of new and changing data. Designed to be offered as a stand-alone online course, a traditional on-campus course or a hybrid offering, the emphasis has been placed on the delivery of up-to- date ocean conditions available from a variety of sensors. Exercises incorporate both current news items and events related to ocean sciences as well as near real-time data from satellites, buoys, and other observation stations.

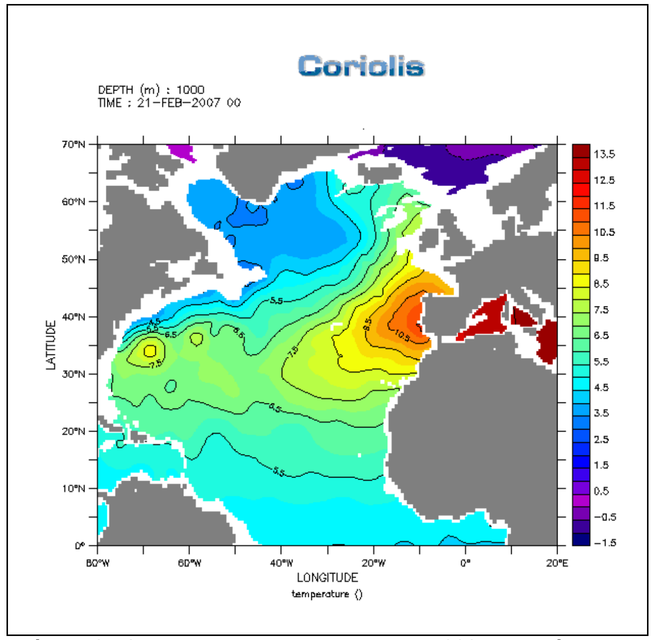

Figure 2. Ocean Water Temperatures at 1000 m Depth. Horizontal pattern of temperature. Note spilling of warm Mediterranean Sea water over the Straight of Gibraltar (right center) (Ch. 6B, Fig. 6, AMS 2007).

One example of the integration of online data relates to the formation and movement of water masses (Fig. 1). The lesson presented in Investigation 6B (AMS 2007) deals with density-driven circulation. Students are given temperature and salinity profiles taken off the coast of Portugal by an APEX profiling float. Students are asked to analyze and interpret the data, and then

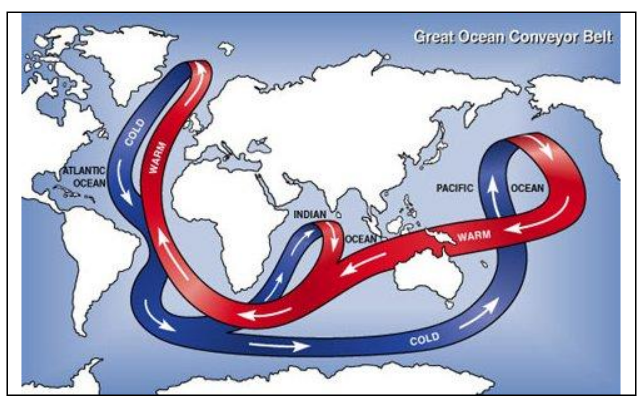

Figure 3. Global Circulation Pattern. Conveyor-like movement of water driven by surface winds and density differences play a key role in the global transport of heat energy (Ch. 12A, Fig. 2; AMS 2007).

apply the temperature and salinity combinations at different depths to determine sea water density. This information is then used to identify different water masses, focusing on the varying origins of waters found at different depths (Fig. 1). The students then use maps of horizontal salinity and temperature distributions at 1000 m depth (Fig. 2) to visualize the movement of Mediterranean Water out of the Mediterranean Sea, as it spills over the sill at the Strait of Gibraltar and into the Atlantic Ocean. Ultimately, in Chapter 12 (AMS 2007) students examine how the combination of wind-drive surface currents and density-driven thermohaline circulation creates global circulation patterns (Fig. 3).

4.2 Applying the Technologies

The discussion of thermohaline circulation can be expanded by asking the students to consider one of the premises the science fiction action film "The Day After Tomorrow" in which the melting of ice in the North Atlantic effects the movement of the Gulf Stream northward (Fig. 4) (cf. Masters 2008). Various points made in the film can be explored to determine their

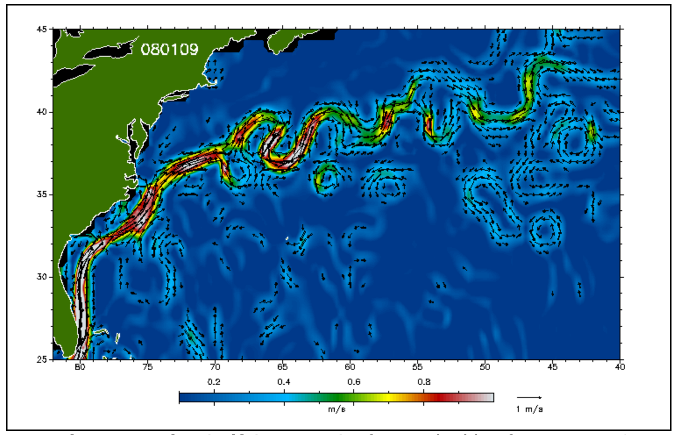

Figure 4. The Gulf Stream. Surface velocities for January 9, 2008 demonstrate how this current transports equatorial heat energy northward. Gulf Stream velocity fields are derived from near real-time data from the radar altimeters of the satellites Envisat, Jason-1, TOPEX/Poseidon, and GFO (Courtesy of Department of Earth Observation and Space Systems, Delft University of Technology).

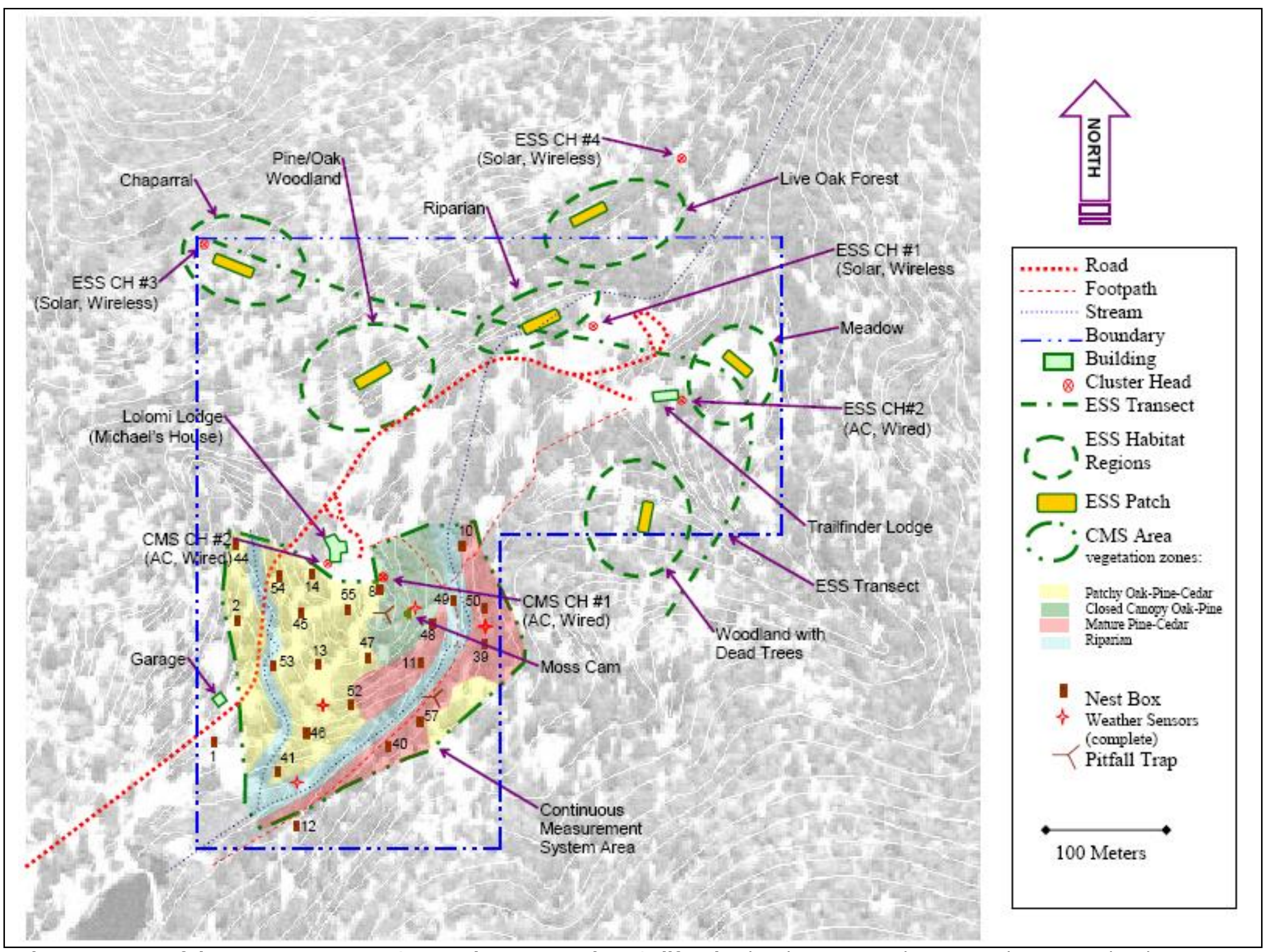

Figure 5. Map of the James Reserve, San Jacinto Mountains, California showing topography, vegetation zones, hardware platforms (wireless mote class sensor networks, ESS and CMS), reserve infrastructure, weather sensors, pitfall traps and a partial map of nest box locations (Courtesy of CENS).

scientific validity, and thereby increase student interest and understanding of key concepts.

4.3 Center for Embedded Networked Sensing

Another online resource that provides authentic field research opportunities is the Center for Embedded Networked Sensing (CENS). This National Science Foundation Science and Technology Center housed at the University of California Los Angeles specializes in the deployment, monitoring and maintenance of arrays of sensors that deliver information about the physical world (Hamilton et al. 2007).

CENS has their Terrestrial Ecology Observing System sensors deployed at the James Reserve (part of the University of California Natural Reserve System) located in the San Jacinto Mountains near Idyllwild, California. These sensors include plant and animal observing systems, soil environment sensors, microclimate sensors and meteorological stations (Fig. 5). The James Reserve also serves as a test bed for prototype deployment for the National Ecological Observatory Network (NEON) project.

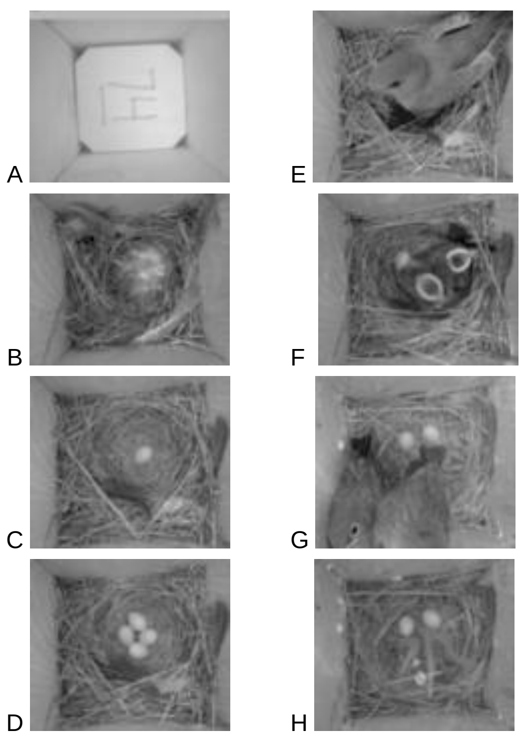

Figure 6. Images from nest box camera 708, May – July, 2007. A. empty nest box; **B.** nesting materials; **C.** first egg laid; **D.** total clutch size; **E.** parent incubating eggs; **F.** hatch success/chicks begging for food; **G.** juvenile chicks; **H.** fledging completed. Note unhatched eggs (James Reserve unpublished data).

Among other sensors are an array of cell phone-like Cyclops cameras that deliver time-lapse photographs of a series of nest boxes at the reserve every 15 minutes (Fig. 6). In the Field Ecology course at CSU-Pueblo (a fall course) students will be asked to analyze data for the previous spring and summer that captures various aspects of bird behavior and reproduction. Students may choose to use these data in a variety of manners, exploring such questions as the dates of first occupancy, nest building, egg laying, and fledging of young. Students can also explore activity patterns of the birds (diel patterns of incubation, foraging, begging, feeding), life history patterns (total clutch size, hatching success, maturation rate), or comparisons of nesting patterns and behaviors with local birds (Fig. 6). While scientists and engineers affiliated with CENS are exploring the possibility of automating the collection of data on avian behavior and nesting cycles (Ko 2007; Ahmadian et al. 2007), there are remains plenty of opportunity for students to make visual observations and analyze data.

Other sensors at the James Reserve site that may be incorporated into student research projects include live cameras of bird feeders, vegetation and the local habitat; meteorological measurements, and microclimate measurements taken inside selected nest boxes (Hamilton et al. 2007).

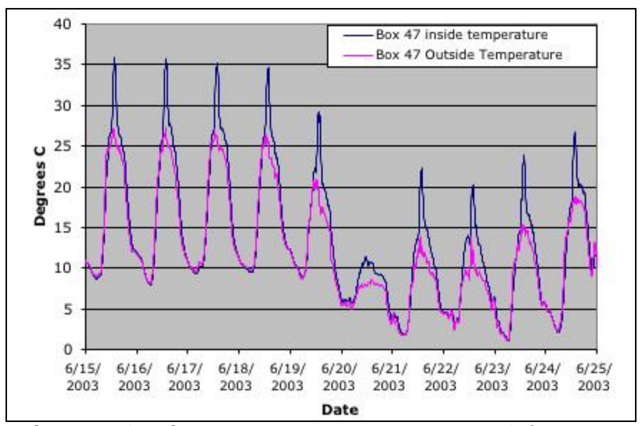

Figure 7. Continuous Nest Box Temperatures. Select nest boxes at James Reserve are equipped with sensors that make continuous measurements of internal and external temperature and humidity (James Reserve unpublished data).

The numerous and varied current, near real-time and archive data and images allow for a lot of flexibility in the design of student research projects/experiences. For an example of nest box analysis, see work by Hamilton (2007) or Ahmadian and their associates (2007).

5. CONCLUSIONS

From the examples above it is clear that the varied and easily accessible data on the Internet can be incorporated into a variety of course exercises and research experiences. For students at resource-poor institutions this opportunity represents a major step towards reaching parity in educational experiences with their counterparts at large research institutions. Ultimately, such leveling of the playing field may play a key role in the ability of coming generations to deal with changes in the world around us.

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