P1.34 TEACHING METEOROLOGY AT THE UNIVERSITY OF TEXAS, EL PASO

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1. INTRODUCTION

The University of Texas at El Paso (UTEP) began offering the American Meteorological Society (AMS) Online Weather Studies (OWS) curriculum in fall 2005. This paper provides a background to the university and its educational role, the meteorological aspects of the El Paso region which facilitate student interest and instruction in atmospheric phenomena, and details of how OWS and related courses are being implemented at UTEP.

2. THE UNIVERSITY OF TEXAS AT EL PASO

According to the institution's history presented on its official web site (http://www.utep.edu), UTEP began when Texas Governor O.B. Colquitt signed Senate Bill 183 in 1913, creating the State School of Mines and Metallurgy in El Paso. The Texas School of Mines enrolled its first students in 1922. In 1949, the institution was renamed Texas Western College, and became the University of Texas at El Paso in 1967. As such, UTEP is the second oldest academic component of the University of Texas system. UTEP is now a Carnegie "Doctoral-Research Intensive University" with six colleges and a graduate school, offering bachelor's, master's, and doctoral degrees in a number of disciplines. Current UTEP enrollment approaches 19,000 students (approximately 80% undergraduate and 20% graduate).

UTEP is a Minority Institution, with over 80% nonwhite enrollment: it is the only major research university in the USA whose students are primarily Mexican-American and the largest university in the nation with a primarily Mexican-American student body. UTEP is consistently one of the top universities in the nation in conferring bachelor's and masters degrees to Hispanic students. In addition, UTEP's enrollment also is comprised of approximately 11% Mexican citizens, giving it one of the largest Mexican National student populations of any USA university. UTEP is widely regarded as a model institution for involving Hispanic students in research and one of the leading universities in the nation in the provision of college degrees in science and technology to Hispanic students.

Demographics of the student body obtained from various UTEP sources suggest that the campus serves primarily a local populace and regional Mexican nationals, with over 80% of the enrolled students being from El Paso County, Texas (the majority of El Paso's university-bound students attend UTEP). Approximately sixty percent of the student body are first-generation college students: the average ages of undergraduate and graduate students are 24 and 36. The university web portal states that UTEP seeks to "extend the greatest possible educational access to a region that has been geographically isolated with limited economic and educational opportunities for many of its people."

3. GEOGRAPHY AND METEOROLOGY OF EL PASO AND THE SURROUNDING REGION

3.1 Demographics

The city of El Paso and El Paso County are located at the extreme westernmost edge of Texas, adjoining the state of New Mexico and the Mexican state of Chihuahua. Some suburbs such as the city of Sunland Park lie across the state line in New Mexico. The Mexican city of Ciudad Juarez is contiguous to El Paso, separated by the Rio Grande (Rio Bravo del Norte) river which forms the international boundary after flowing through the Paso del Norte (Pass of the North) from New Mexico. Founded by missionaries and explorers more than 300 years ago, El Paso currently ranks as the 21st largest city in the USA and 6th largest city in Texas, with a population of approximately 600,000. The combined Paso del

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Norte binational metropolitan area's current population of over 2.2 million makes it one of the largest metropolitan areas on the USA-Mexico border, and one of the 50 largest metropolitan areas in the Western Hemisphere. It is a geographically isolated metropolitan area, more than 550 km east of its nearest large (pop. > 1 million) conurbation (Phoenix, Arizona).

3.2 Physical geography

The Paso del Norte region lies in southwestern North America, in the Chihuahuan Desert of the Basin and Range geomorphic province. The metropolitan area has strong variations in topography, with the Sierra de Juarez providing a southwestern backdrop to Ciudad Juarez, the Franklin Mountains nearly bisecting the city of El Paso, and Mount Cristo Rey and the Rio Grande Rift fringing the metropolitan area in New Mexico. To the east and the west, the desert spreads out in a relatively flat sandy plain.

El Paso is located at 31°47′ N, 106°25′ W (31.79, -106.42). Surface elevations range from approximately 1143 meters (3750 feet) above sea level along the river to 2193 meters (7192 feet) at North Franklin Mountain.

3.3 Climate and weather

El Paso's nickname is the "Sun City," and rightly so. According to data from the National Weather Service El Paso Forecast Office (NWS ELP), the city receives 88.2% of the possible sunshine, and experiences over 300 sunny days per year (Figure 1). Sellers (1965) shows the El Paso area as receiving an average annual horizontal ground-level solar radiation of approximately 200 kilolangleys per year, near the maximum for the Western Hemisphere.

The region has an arid, warm climate: data posted on the NWS ELP web site (http://www.srh.noaa.gov/elp) indicate that El Paso has an average annual maximum temperature of 25.1 degrees Celsius and an average annual minimum of 11.2 degrees. Temperature averages range from a high of 35.2 degrees Celsius in June to a low of 0.5 degrees Celsius in January. Average annual precipitation is 21.8 centimeters, with infrequent winter snowfalls. Hot (maximum temperature >40 degrees Celsius), dry days are most common in late spring before the monsoon arrives, while freezing weather is most common in December and January.

Figure 1. Clear days are predominant in El Paso (Looking southwest from a west El Paso hillslope: Sierra de Juarez, Chihuahua, Mexico, in distance).

Continental tropical (dry desert) air masses dominate El Paso's weather, although sensible synoptic weather is often caused by air masses intruding from surrounding regions. Cold continental air masses advecting from the northeast regularly bring sudden spells of chilly winter weather. Occasional Pacific fronts bring wind and rare precipitation in autumn, winter, and spring, and Gulf air occasionally approaches from the east in spring and early summer. Drylines may rarely penetrate as far west as the El Paso metropolitan area. The predominant rainy season (Figure 2) is produced by the North American southwest monsoon, with more than half the average annual precipitation (12.3 cm) falling in July, August, and September. Strong El Niňos have produced the wettest and snowiest cool seasons (autumn- winter- spring) in El Paso, while moisture from Pacific tropical cyclones may rarely reach the region and bring additional rains.

Figure 2. Monsoon thundershower over the Chihuahuan Desert west of El Paso, August 2005.

Mesoscale atmospheric processes are often quite evident in El Paso. The Franklin Mountains rise high enough into the atmosphere to produce clouds and enhance precipitation through orographic uplift (Figure 3). The range also experiences slight anabatic-katabatic breezes, as well as strong downslope wind events (Reynolds and MacBlain, und.). Drainage-related flows are experienced in the Rio Grande rift and valley. Temperature differences between the built-up urban area and the sparsely populated Chihuahuan Desert surroundings produce a heat island effect. The region experiences significant dry-season and thunderstorm-outflow dust storms (e.g. Gill *et a*l., 2000: Doggett *et al*., 2002) (Figure 4). While "winter weather," tornadoes, and large hail are infrequent in El Paso, the area regularly experiences severe weather in the form of flash floods, high winds, lightning, and heat.

Figure 3. Orographic uplift can aid formation of clouds over the Franklin Mountains.

Figure 4. Blowing dust obscurring visibility (view similar to Figure 1).

The geographical setting of the Paso del Norte borderlands- an isolated large urban area in a desert surrounded by complex topography, often at the meeting point of air masses- results in many sensible meteorological phenomena provoking interest in citizens and students. Weather-related issues such as air quality (the metropolitan area experiences noticeable air pollution: e.g. Noble *et al*., 2003: Garcia *et al.*, 2004) and water supply (El Paso and Ciudad Juarez are growing cities in an arid climate with uncertain water resources requiring innovative methods to meet the water needs of their residents; e.g. Sheng, 2005)) are key issues of ongoing concern to El Paso residents and have demonstrable economic and environmental impacts on the local community. These facts are used to promote meteorology as an important facet of scientific and environmental education at UTEP, and to illustrate atmospheric processes and meteorological concepts to UTEP students.

4. TEACHING METEOROLOGY AT UTEP

4.1 Courses offered

The primary mode of teaching about the atmosphere at UTEP has been through the course Geography (GEOG) 3306, a 3-unit, junior-level science elective class traditionally provided as 3 hours of in-class lecture per week (no laboratory). However, with the diminution of UTEP's Geography program in the past decade, and the retirement of pre-existing physical geography faculty members, it had become more difficult to offer the course. With the hiring of the author (who has a bachelor's degree in atmospheric science and was previously a research faculty member in Texas Tech University's Atmospheric Science Group) as a UTEP faculty member in 2004, and UTEP's participation in the AMS OWS curriculum, the class will be offered on a regular basis.

Elements of weather, climate, and meteorology also are included within several other undergraduate courses at UTEP. Geology (GEOL) 1303, Introduction to Earth Science, is an entry-level science class (3 units: 2 hours lecture per week plus 2 hours laboratory, taught by various faculty in Geological Sciences) required for many UTEP majors, and typically is offered in multiple sections each semester enrolling hundreds of students. One of the four "blocks" of the course comprises weather and climate, in which students receive approximately three weeks of lectures and several laboratory exercises in basic atmospheric science. GEOG 1306, Physical Geography, is an introductory course which includes significant instruction in weather

and climate; the course is now regularly taught by UTEP's Provost, Dr. Richard Jarvis, a physical geographer by training. In addition, several UTEP research centers including the NASA-sponsored Pan American Center for Environmental Studies (PACES) and the EPA-supported Center for Environmental Resource Management (CERM) regularly provide selected atmospheric-related resources and data (primarily in remote sensing and air quality) to UTEP students participating in the centers' research projects.

In Spring 2005, the author developed and introduced a unique graduate-level "Atmospheric and Meteorological processes" class (GEOL 4315 -5315 -6315), providing a mathematically rigorous and comprehensive yet practical introduction to meteorology to advanced science and engineering students without any previous weather-related training or coursework. The course attracted a few upper-division undergraduate students in the Environmental Science and Biology majors: however, the majority of the enrollees were master's or doctoral level students in Geology, Geophysics, Environmental Science (M.S.) or Environmental Science and Engineering (Ph.D). 75% of the enrollees were Hispanic. This course was offered as three hours of lecture per week, with Stull (1999) required as the textbook. Students were required to regularly access the NWS ELP web page and interpret local weather conditions and forecasts, and each afternoon's Area Forecast Discussion was used as a teaching aid for every lecture. Practicing meteorologists from the White Sands Missile Range and the NWS ELP provided guest lectures. Each student was required to complete a rigorous term paper/ project on an atmospheric topic of their choosing, formatted as if it were a manuscript submitted to the *Bulletin of the American Meteorological Society*, and make a 20-minute oral presentation given as per a talk at an AMS conference. The instructor encouraged two of the students to submit their presentations/papers to professional meetings or journals, and two other enrollees are now pursuing atmospheric-science-related thesis projects in Environmental Science and presenting papers at the 2006 Annual Meeting (Emmert and Gill, 2006: Rivera *et al.*, 2006).

4.2 Online Weather Studies at UTEP

The AMS contacted UTEP's Geological Sciences Department during the spring semester of 2005 with an invitation to participate in their Geoscience Diversity Project and offer Online Weather Studies. The department and the author agreed to offer the Online Weather Studies curriculum as the GEOG 3306 course beginning in the Fall 2005 semester. The author attended the AMS-sponsored Online Weather Studies faculty workshop in May 2005 and began preparing the new GEOG 3306 curriculum during the summer.

As currently implemented at UTEP, Online Weather Studies and GEOG 3306 remains a 3-credit lecture-based course. The author has developed weekly lectures for classroom delivery matching and supplementing the topics covered in the textbook (Moran, 2002) from which weekly readings are required. UTEP utilizes the webCT courseware: for GEOG 3306, each week's illustrated in-class lectures are posted on the class webCT portal as Adobe Acrobat files. Learning objectives for each chapter and other supplemental materials are also provided on webCT, as well as convenient links to the AMS OWS homepage and the NWS ELP web site. Students are expected to log in to the OWS home page to read the daily weather summaries and supplemental information. Additional readings from the popular and scientific meteorological literature are also assigned in class. Homework from the accompanying Investigations Manual (including the online portion) is required for weekly completion by the students: however, only one of the two investigations per chapter and/or selected Critical Thinking and review questions are typically assigned. All homework assignments are turned in and all examinations are delivered in class. Each student is also required to maintain a daily "weather journal" which is expected to not only summarize their observations of sensible weather in terms of what they have learned in the course, but also increase in sophistication as the semester progresses. The students turn in their weather journals for assessment while taking each in-class examination.

Whenever appropriate, "the view out the window" is used to illustrate meteorological concepts via the weather occurring at class time (Figure 5). The classroom presently used for GEOG 3306 is adjacent to a large windowed hallway on the top floor of the UTEP Geological Sciences Building providing a panoramic view of the sky to the east and west. Whenever feasible, students are asked to gather in the hallway or outdoors to interpret and discuss the atmospheric phenomena visible at class time and to illustrate the topics being covered in each lecture.

Figure 5. The "view out the window" from the top floor of the UTEP Geological Sciences Building is used to illustrate concepts provided in Online Weather Studies before each lecture. (Photo by Sonny Emmert)

When the GEOG 3306 / Online Weather Studies course was first offered at UTEP in Fall 2005, enrollment was somewhat limited due to the initial roll-out of the course under the AMS curriculum. Seventeen undergraduates, mostly members of ethnic minority groups (including Hispanic, African- American, Native American, and Asian- American) were on track to complete the course. The majority of the students were Environmental Science majors, although Biology and Geology majors also enrolled. Surprisingly, several History majors also signed up for the class: anecdotal reports suggest this may be due to the Geography requirements for students seeking to become social science teachers in the Texas public schools.

5. IMPLICATIONS

The OWS curriculum is an excellent way to connect UTEP and its students with local NOAA resources: guest lecture(s) from National Weather Service forecasters, other professional meteorologists, and a field trip to the National Weather Service Forecast Office- El Paso (NWSFO ELP) are or will be used to illustrate practical applications of and potential internship and career opportunities in atmospheric science. UTEP students participating in targeted internship programs including SOARS (Significant Opportunities for Atmospheric Research and Science) are also invited to speak to the Online Weather Studies/ GEOG 3306 class.

UTEP is a partner institution of Howard University's NOAA Center for Atmospheric Sciences, and through this relationship, a pipeline exists for UTEP students to consider entering Howard's graduate program in atmospheric science. Increasing student interest in meteorology and climate through Online Weather Studies may inspire UTEP students to pursue a graduate course of study in atmospheric science at Howard or elsewhere, increasing the diversity of our nation's professional meteorological workforce.

In 2003, UTEP received a grant from NOAA to provide "curriculum development and enhancement of outreach in the environmental sciences." The objectives of this project were to augment exposure of Environmental Science students to topics related to the atmosphere, weather, and climate: to improve and redesign course content for classes including GEOG 3306; to strengthen other learning experiences for Environmental Science students: and to improve UTEP's relationship with NOAA. Sub-objectives of the project are stated to "expose students to the wealth of atmospheric and oceanic information that is available on-line" and "reinforce the role that ocean and atmospheric science play in environmental science." UTEP's participation in the Online Weather Studies program will only strengthen all these objectives.

UTEP is moving towards increasing course offerings and enhancing student learning in the atmospheric and related sciences, primarily through integration of meteorological materials into its environmental science curricula. Participation in the American Meteorological Society (AMS)'s Diversity Project and the educational grant from NOAA have allowed UTEP to strengthen its environmental science offerings by adding and deepening meteorological- related courses, outreach programs, and research and career opportunities for students. Although available to any UTEP student, these programs are of particular interest to students in the BS/MS programs in Environmental Science and the doctoral program in Environmental Science and Engineering, as well as students majoring in Geology, Biology, and other sciences. GEOG 3306 at UTEP is currently a suggested elective for undergraduate students pursuing most options within the Environmental Science major, and for one option within the Geology major. In addition, it should provide an attractive science elective for undergraduate students in many majors.

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