The National Weather Center REU Visiting Faculty Program

Dr. Wilson J. González-Espada, Department of Physical Science, Arkansas Tech University
wilson.gonzalezespad@mail.atu.edu.

The paper describes my professional and personal experiences as the first visiting faculty at the National Weather Center REU Program, including a brief rationale for undergraduate research, historical background of the research experience, descriptions of some of the projects in which I was involved, and a summary of four of the conferences I attended.

The importance of Research Experiences for Undergraduates (REU) has been widely extolled in the literature. Extensive research suggests that there are several benefits of REU programs, such as increased self-confidence and motivation, the contribution of research material to the discipline, improved research skills, a better understanding of complex scientific concepts, graduate school and career clarification, and continued development of critical thinking skills. In addition, REU experiences increase the retention and graduation of underrepresented students in science and mathematics (Bauer and Bennett, 2003; Kremer and Bringle, 1990; Seymour et al, 2004). Because of these benefits, a number of universities and scientific governmental institutions have decided to provide undergraduate students with expanding research opportunities.

In 1987, one of the National Weather Center (NWC) institutions, NOAA's National Severe Storms Laboratory established an "undergraduate summer employment program" to address the scarcity of undergraduate students interested in meteorology and to introduce undergraduates to the "business of scientific research" (Lewis and Maddox, 1991). This program was designed to emulate similar programs in existence in the 1960s and 70s at NOAA's Experimental Meteorology Laboratory at Coral Gables, Florida, and the National Center for Atmospheric Research's Summer Employment Program at Boulder, Colorado (Armhols and Woodley, 1975). Since 1991, most summer programs have been supported wholly or in part by a National Science Foundation REU grant.

The positive impact of the NWC REU program has been documented from its beginnings through student evaluations. These results are consistent with other science REU programs (Lewis and Maddox, 1991). For example, around the mid 1990s, Cortinas Jr. et al. (1996) summarized the successes of the REU program up to then and summarized the evaluation of the 1995 program. They found that the NWS REU program reinforced most students' decision of attending graduate school and that all students felt better informed about career options in meteorology, with some of them considering a research career seriously. Similar reports of the continuing positive impact of the NWS REU program were disseminated several years later at professional meteorology meetings (Palmer, 1999; Palmer, Stevenson, and Zaras, 2000).

In its latest form, the NWC REU program has continued to use mentor and student feedback in order to evaluate the program and refine what they now identify as best practices (Zaras, 2005). In the last 5 years, the NWS REU program has been structured so that students participate in numerous workshops, field trips, and lectures. All students are required to complete a 10-page paper on their work and are provided funding to present their findings at a meeting of the American Meteorological Society.

For the summer of 2005 an interesting new feature was added to the REU program: the opportunity for a visiting faculty to co-mentor students. The rationale for this new position is summarized by Zaras (2005):

> [The REU] program is forced to turn down more good students than we can accept each year … We are actively recruiting to bring in a visiting faculty to co-mentor students in the 2005 program. This activity may also accomplish a number of additional objectives: invigorate the career of someone in a smaller institution with few resources for research, provide a unique opportunity for professional growth of non tenured and/or non tenure

> track faculty at any size institution, or infuse new research techniques from other fields. We are seeking faculty employed in meteorology or a related field, or in a field where research methodologies might apply to meteorological problems (p. 5).

Fortunately, my physics and science education backgrounds helped me get accepted to the program. My principal task was to mentor an REU student on a project assessing the effectiveness of a distance learning course for entry-level meteorologists taught by the National Weather Service's Warning Decision Training Branch (Grant, 2005; Grant et al, 2004; Mostek et al, 2003, Mostek et al, 2002).

I co-mentored a junior earth and atmospheric science major from Georgia Institute of Technology. Along with Brad Grant, a meteorology instructor from the Warning Decision Training Branch (WDTB), we decided to offer one of the Distance Learning Operations Course (DLOC) tests on convective storms as a post-test to determine how much of the course material the participants remembered after six months (2005 group) and one year (2004 group). In addition, a 1-9 modified Likert-type survey (Borg and Gall, 1989) was designed for the participants to evaluate how many of the main topics of the DLOC course they apply in their current positions at the several National Weather Service offices across the United States.

After the REU student performed the statistical analysis, he found that pre-test scores for participants in the study were not statistically different from pre-test scores of non-participants, suggesting that the self-selected group of participants represents the population of interest. Also, a statistically significant difference in pre- and post-test scores was found for both groups of interest (2004 and 2005 DLOC alumni). The average post-test scores were still higher than the 70% passing rate determined by the course instructor. Chi-square tests that compared the number of correct and incorrect responses for each item and each test administration pointed out items where participant performance was significantly lower. Since some items are used in subsequent years, these items were flagged to be revised for future test administrations.

On a 1-9 Likert scale, participants reported to what extent they apply nine of the most important DLOC concepts. They reported consistently high applicability of the course, regardless of the geographic region of residence. Correlations between the post-test scores and the reported applicability levels were significant for the 2004 group, but not for 2005. This suggests that it takes about a year for the course material to be fully applied in most job areas. Although the REU student had no experience in educational research, he learned a lot about assessment, test design, and statistics. In addition, he was able to keep the DLOC course materials, which provide a nice summary of radar applications during severe weather. The results of our collaboration were presented at the 2006 American Meteorological Society meeting (Miller, Grant, and González-Espada, 2006).

With the collaboration of Daphne Zaras, meteorologist and director of the NWS REU program, and using both quantitative and qualitative data from several surveys, we wrote a paper on the impact of the research experience on the participants. We found a positive, statistically significant difference between the REU participant's plan to go to graduate school before and after the program. No statistically significant difference was found on the students' career plans and self-efficacy on becoming research scientists before and after the program. The qualitative analysis provided a context from which the statistical data can be interpreted, especially the non-significant results. Our research results were presented at two professional meetings (González-Espada and Zaras, 2006; González-Espada and Zaras, 2005).

I also developed a collaborative relationship with three scientists who were interested in measuring students' misconceptions about relative humidity but were not sure exactly how. With the help of the University of Oklahoma's superb History of Science Collection, I was able to write a historical background on the concept of relative humidity (for a summary, see Feldman 1983; Frisinger 1977) and to help develop a questionnaire to be administered to freshman college students. Our results were presented at two professional meetings (Heinselman, Zaras, Fredrickson, and González-Espada, 2006; González-Espada, 2005).

Tapping into the expertise of some of the scientists and engineers at the National Severe Storms Laboratory, I revised a previous paper on the use of Doppler techniques to determine the acceleration of gravity of a falling buzzer (González-Espada and Robertson, 2002). Dr. Sebastian Torres, a research scientist and electrical engineer, used fundamental research in the field of digital signal processing (Boashash, 1992) to derive a more precise way to analyze sound data and to plot instantaneous frequency as a function of time, from which the slope of the best-fit line was used to calculate the acceleration of gravity. The resulting manuscript will be published in the journal The Physics Teacher in the fall of 2006.

Throughout the summer, I had the opportunity to tour the National Weather Service, the National Severe Storms Laboratory, the Phased Array Radar, the Storm Prediction Center, and the University of Oklahoma's School of Meteorology and Supercomputing Center with the visiting students. Seeing in person how meteorologists collect and analyze the data to transform computer models to daily forecasts is a very thrilling experience.

Fortunately, I was able to attend several of the professional development seminars offered by the University of Oklahoma's School of Meteorology. Among them was a conference by Dr. Rodger Brown on simulated Doppler radar signatures of tornadoes. He is one of the scientists that discovered the Tornadic Vortex Signature (TVS), an intense, concentrated rotation that sometimes precedes a tornado and is commonly used to issue tornado warnings. TVS is not a visually observable feature. It can only be detected using a Doppler radar (Brown and Lemon; 1976; Brown, Lemon, and Burgess, 1978). I also attended a seminar by Dr. Greg Holland on equatorial wave confluence zones and tropical cyclone development. In his talk, Dr. Holland described necessary and sufficient large- and meso-scale conditions for tropical cyclone genesis. Some of his work is described in Ritchie and Holland (1999) and Holland (1999).

I was able to take part in a very interesting presentation by Dr. Elaine Seymour, a renowned educational researcher and author of a well-read book on why undergraduates leave the sciences (Seymour and Hewitt, 2000). She was discussing her new findings on student gains from participating in undergraduate research experiences (Seymour, Hunter, Laursen, and Deantoni, 2004). In addition, I attended a symposium on anthropogenic influences on global warming led by Dr. David Karoly, one of the participants of the Intergovernmental Panel on Climate Change. He argued that evidence from direct measurements of surface air temperature, subsurface ocean temperature, glaciers, ice cores, and tree rings suggests that a significant global warming is occurring. He believes that Carbon-14 analysis of atmospheric carbon dioxide points at the burning of fossil fuels as mostly responsible for global warning (Houghton et al, 2001; Folland et al, 1998; Karoly and Braganza, 2001; Karoly, 2003).

Not only did I attend a number of seminars, but I also had an opportunity to prepare a talk on the role of professional scientists in K-12 education, in which I argued that there has traditionally been a gap between those who teach school science and those who do science. Teachers, on one hand, are expected to teach how science works without significant research training. Scientists, on the other hand, are experts on how science works but they are rarely involved in school science education. In this talk I proposed that scientists should get involved in K-12 science by helping teachers to (a) correct any misconceptions about scientists, (b) align their talks to national and state science standards, and (c) develop partnerships with practicing scientists, (d) help science students to clarify their misconceptions about science and scientists, (e) challenge pseudoscientific ideas, (f) endeavor to shift the perception of scientists from authorities to experts, (g) counsel about science career options, and (h) encourage students from underrepresented groups to consider science as a viable career option. An expanded version of this talk was presented at a regional meeting of the American Association for the Advancement of science (González-Espada, 2006).

In addition, I was able to collaborate in other works in progress. For example, another REU student needed my help in translating a consent form and a questionnaire from English to Spanish for her research project on weather awareness among Hispanics living in Oklahoma City.

This was an especially busy and enriching experience, both professionally and personally. I met twelve outstanding undergraduate students with strong motivation to do research and to learn more about meteorology. I met a number of scientists who received me with open arms, helped me gain a better appreciation for the field of meteorology, and updated my content background on weather forecasting and severe weather research. The NWS REU Visiting Faculty Program was an excellent experience that should be replicated in other REU programs as an opportunity for physical science and/or science education faculty members to mentor undergraduate student research. Those interested in a challenging and rewarding summer should contact the Cooperative Institute for Mesoscale Meteorological Studies or the National Weather Service.

This publication was made possible by NSF REU Grant # 0097651; under the direction of Daphne S. Zaras, NWC REU, 1313 Halley Circle, Norman, OK 73069 (www.caps.ou.edu/reu). Its content is solely the responsibility of the author and does not necessarily represent the official views of NSF.

References

Armhols, C. A. and W. L. Woodley. 1975. Teaching and learning with youth. *Bulletin of the American Meteorological Society* 56(1): 41-44.

Bauer, K. W. and J. S. Bennett. 2003. Alumni perceptions used to assess undergraduate research experiences. *Journal of Higher Education* 74(2): 210-230.

Boashash, B. 1992. Estimating and interpreting the instantaneous frequency of a signal – Part 1: Fundamentals. *Proceedings of the Institute of Electrical & Electronics Engineers* 80(4): 520-538.

Borg, W. R. and M. D. Gall. 1989. *Educational research: An introduction*. New York: Longman.

Brown, R. A., L. R. Lemon, and D. W. Burgess. 1978. Tornado detection by pulsed Doppler radar. *Monthly Weather Review* 106(1): 29–38.

Brown, R. A., and L. R. Lemon. 1976. *Single Doppler radar vortex recognition: Part II -Tornadic vortex signature*s. Paper presented at the 17th Conference on Radar Meteorology, American Meteorological Society, Seattle, WA, 26-29 October.

Cortinas, J. V., J. M. Straka, W. H. Beasley, J. M., Schneider, and C. M. Machacek. 1996. The Research Experience for Undergraduates Program: The 1995 program at the Oklahoma Weather Center. *Bulletin of the American Meteorological Society* 77(12): 2925-2936.

Feldman, T. S. 1983. *The history of meteorology 1750-1800: A study in the quantification of experimental physics*. Unpublished doctoral dissertation, University of California, Berkeley.

Folland, C. K., D. M. H. Sexton, D. J. Karoly, C. E. Johnson, D. P. Rowell, and D. E. Parker. 1998. Influences of anthropogenic and oceanic fording on recent climate change. *Geophysical Research Letters* 25(3): 353-356.

Frisinger, H. H. 1977. *The history of meteorology to 1800*. New York: American Meteorological Society (Science History Publications).

González-Espada, Wilson J. 2006. *The essential role of professional scientists in K-12 science education*. Paper presented at the 81st meeting of the American Association for the Advancement of Science (Southwest and Rocky Mountain Section), April 5-8, Tulsa University, Tulsa, OK.

González-Espada, Wilson J. and D. Zaras. 2006. *Evaluation of the impact of the NWC REU Program compared with other undergraduate research experiences*. Poster presented at the 2006 15th Symposium on Education, January 28, American Meteorological Society Meeting. Atlanta, GA.

González-Espada, Wilson J. and D. Zaras. 2005. *Administration, best practices, and evaluation of the National Weather Center REU Program*. Poster presented at the 2005 meeting of the American Geographical Union, San Francisco, CA.

González-Espada, Wilson J. 2005. *Developing a survey to detect relative humidity misconceptions*. Paper presented at the annual meeting of the Arkansas, Oklahoma, and Kansas section of the American Association of Physics Teachers, October 7-8, Oklahoma City Community College, Oklahoma City, OK.

González-Espada, W. J. and J. Robertson. 2002. *The Doppler Effect for a constantly accelerating sound source receding from a stationary observer: Determining the acceleration of gravity based on acoustic data*. Paper presented at the Annual Meeting of the Arkansas Academy of Science. Little Rock, April 2002.

Grant, B. N. 2005. *Evaluation of NOAA's National Weather Service Advance Warning Operations Course*. Paper presented at the 21st International Conference on Interactive Information Processing Systems for Meteorology, Oceanography, and Hydrology/14th Symposium on Education, San Diego, CA, 11 January.

Grant, B. N., E. Mahoney, A. Wood, J. LaDue, and X. Yu. 2004. *The winter weather warning decision making workshops*. Paper presented at the 20th Conference on Weather Analysis and Forecasting/16th Conference on Numerical Weather Prediction, Seattle, WA, 13 June.

Heinselman, P., Zaras, D., Fredrickson, S., and González-Espada, W. J. 2006. *Relative humidity: What do students know about it?* Paper presented at the 2006 15th Symposium on Education, January 31, American Meteorological Society Meeting. Atlanta, GA.

Holland, G. J. 1999. The maximum potential intensity of tropical cyclones. *Journal of the Atmospheric Sciences* 54(21): 2519-2541.

Houghton, J.T., Y. Ding, D. J. Griggs, M. Noguer, P. J. van der Linden, and D. Xiaosu. 2001. *IPCC third assessment report on climate change: The scientific basis*. Cambridge: Cambridge University Press.

Karoly, D. J. 2003. Ozone and climate change. *Science* 302: 236-237.

Karoly, D. J., and K. Braganza. 2001. Identifying global climate change using simple indices. *Geophysical Research Letters* 28(11): 2205-2208.

Kremer, J. F. and R. G. Bringle. 1990. The effects of an intensive research experience on the careers of talented undergraduates. *Journal of Research and Development in Education* 24(1): 1-5.

Lewis, J. M. and R. A. Maddox. 1991. The summer employment program at NOAA's National Severe Storms Laboratory: An experiment in the scientific mentorship of undergraduates. *Bulletin of the American Meteorological Society* 72(9): 1362-1372.

Miller, B, B. Grant, and W. González-Espada. 2006. *Evaluating learning and performance in the Warning Decision Training Branch's DLOC and AWOC*. Paper presented at the 2006 15th Symposium on Education, American Meteorological Society Meeting, Atlanta, GA, 31 January.

Mostek, A., S. Bachmeier, T. Whittaker, D. Bikos, D. Lindsey, J. Weaver, M. DeMaria, B. Grant, and J. LaDue. 2003. VISITview: *Connecting instructors with operational forecasters.* Paper presented at the International Conference on Interactive Information and Processing Systems for Meteorology, Oceanography, and Hydrology, American Meteorological Society, Long Beach, CA, 9-13 February.

Mostek, A., S. Bachmeier, T. Whittaker, D. Bikos, B. Motta, B. Zajac, J. Weaver, K. Schrab, B. Grant, and L. LaDue. 2002. *Bringing training to forecasters using VISITview: Review of the program since 1999*. Paper presented at the 18th International Conference on Interactive Information Processing Systems for Meteorology, Oceanography, and Hydrology /11th Symposium on Education, Orlando, FL, 13 January.

Palmer, M. H., S. Stevenson, and D. S. Zaras. 2000. *Student evaluations of the Oklahoma Weather Center REU Program 1995, 1998, and 1999*. Paper presented at the 9th Symposium on Education, American Meteorological Society, Long Beach, CA, Jan. 9.

Palmer, M. H. 1999. *Research experience for undergraduates at the Oklahoma Weather Center: Summer 1998*. Paper presented at the 8th Symposium on Education, American Meteorological Society, Dallas, TX, January 10.

Ritchie, E. A. and G. J. Holland. 1999. Scale interactions during the formation of typhoon Irving. *Monthly Weather Review*: 127(9): 2027-2043.

Seymour, E., A. B. Hunter, S. L. Laursen, and T. Deantoni. 2004. Establishing the benefits of research experiences for undergraduates in the sciences: First findings from a three-year study. *Science Education* 88(4): 493-534.

Seymour, E., and N. M. Hewitt. 2000. *Talking about leaving: Why undergraduates leave the sciences*. Boulder: Westview Press.

Zaras, D. S. 2005. *Activities, findings, and recent developments of the National Weather Center Research Experience for Undergraduates Program*. Paper presented at the 14th Symposium on Education, American Meteorological Society, San Diego, CA, Jan. 11.