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Abstract:
The U.S. Department of Energy award DE-SC0001985 funded the Hofstra University Center for Climate Study (HUCCS) from 29 September 2009 through 1 October 2016. This support enabled several activities over the period of the grant, including 1) the pursuit of several research projects, including sediment coring of coastal marshes, analysis of habitat impact due to climate change, and effects of raindrops of CO_2 transfer; 2) support for multiple graduate and undergraduate students, and sponsorship of research projects that involved high school students; 3) fostering mentoring relationships and networking; 4) the design, creation, and installation of an exhibit on climate change at the Cradle of Aviation Museum in Garden City, NY as an effort of public outreach. A total of 11 presentations at conferences, one book, and one peer-reviewed journal article resulted from these activities.

Subject categories: 58 Geosciences; 54 Environmental Sciences

REPORT:

The U.S. Department of Energy award DE-SC0001985 funded the Hofstra University Center for Climate Study (HUCCS) for a total amount of $462,429 over the period of the grant, from 29 September 2009 through 1 October 2016. This supported several HUCCS activities, including 1) the pursuit of several research projects; 2) support for multiple graduate and undergraduate students, and sponsorship of research projects that involved high school students; 3) fostering mentoring relationships and networking; 4) design, creation, and installation of an exhibit on climate change at the Cradle of Aviation Museum.

1) Research Projects:
This award built capacity at Hofstra University in the area of sediment coring. The acquisition of a concrete vibrator and various attachments to use it as a vibracorer, and the acquisition of grain size analysis equipment, allowed Hofstra faculty members Dr E. Christa Farmer and Dr. J Bret Bennington and their undergraduate students, as well as a number of high school students in the Hofstra University Summer Science Research Program, to learn how to collect and analyze sediment cores in Long Island coastal marshes. The funding for external analyses of trace metal concentrations, radiocarbon values, and Cesium and Lead concentrations allowed investigators to develop new geologic records of storm impacts and environmental histories. The acquisition of basic dendrology equipment will further enable

Hofstra University faculty to study the relationship between weather variables and tree ring development through the use of new weather stations on campus and trees in the campus arboretum.

This award also supported analysis of changes in Long Island habitats due to climate change, finding increased risk from aquatic invasive plants and multiple factors in hatching rates of American wood turtles. These analyses were carried out by graduate students under the supervision of Dr. Myla Aronson and Dr. Russel Burke; see below for details.

Finally, this award supported investigation of effects of impinging raindrops on the CO_2 transfer at the air-water interface, as a function of rainrate and wind speed, simultaneously. This analysis was based on an extension of the work by Komori, et al [2007] and Takagaki and Komori [2007]. Their results are based on a laboratory measurement program, which was limited to controlling the rainrate, dropsize (only a uniform value), terminal drop (impinging) velocity and the water channel current. No combined effect of wind and rain was possible. Their investigation included evaluating the relative dominance of the mean kinetic energy flux (KEF) and mean vertical momentum flux (MF) of raindrops. Their findings indicated the MF is the most suitable rain parameter for estimating the CO_2 transfer across the interface. The resulting formula is:

MF = (density of water-> ρ) X (rainrate-> R) X(impinging velocity -> v_p.)

Since no wind was present, v_p was only the result of a gravity driven fall. In the open ocean this is usually less than 9 m/s for the largest drops. They determined an empirical relation between MF and the mass transfer velocity of CO_2, kLR.

In order to make this effect more representative of ocean conditions, Dr. David Weissman chose to extend their analysis and results by including a wind vector, in v_p, to observe how this might change MF and the respective kLR. We used Komori's [2007] empirical relation between kLR and MF to derive kLR as a function of both rainrate and wind magnitude. We modeled natural rain events by using a Marshall-Palmer raindrop size distribution functions, which depend on rainrate. The mean dropsize for each rainrate provides a specific mean terminal velocity. The effect of wind was modeled by calculating the total impinging velocity as the vector sum of the vertical rainfall velocity and the horizontal wind velocity. This reflects the fact that both gravity and the horizontal wind act as orthogonal forces on each drop, but with a different net effect for each size raindrop. Using the empirical model between kLR and MF determined from Komori's empirical measurements, and the equation above, relationships between kLR and rainrate have been developed. The final results here show that both rain and wind speed have comparable and cumulative effects on the transfer of CO2 across the interface.

2) Support for Multiple Students:

a) Graduate Students:

This award supported three (3) students pursuing M.S. degrees at Hofstra University. Natalie Koncki conducted research that led to the completion of her thesis *Invasion risk in a warmer world: Range expansion and habitat preference of three native aquatic invasive plants* in 2012 under the supervision of Dr. Myla Aaronson. This project used the maximum entropy model Maxent to model the future range expansion of three invasive aquatic plant species under current, 2040, and 2080 climate scenarios. The project showed that with future climate change, all of these species will expand their ranges and lakes and ponds are at increased risk for future invasion. This work was recently published in a peer-reviewed journal (Koncki, N.G. and Aronson, M.F., 2015. Invasion Risk in a Warmer World: Modeling Range Expansion and Habitat Preferences of Three Nonnative Aquatic Invasive Plants. *Invasive Plant Science and Management*, 8(4), pp.436-449).

Thomas Duchak successfully defended his M.S. thesis *Hatch rates in a threatened turtle population are influenced by maternal identity as much as random environmental factors* in 2016 under the supervision of Dr. Russell Burke. This project focused on a population of North American wood turtles (Glyptemys insculpta), a species that has experienced drastic, range-wide population declines since the mid-1900s. Three consecutive years of nesting data (including temperatures and soil moisture) were collected at a communal nesting site; hatching success was found to be unusually low and revealed that many females consistently produced clutches with low hatching success rates regardless of incubation conditions. In contrast, hatching success rates of other females were either consistently high. This study indicates that the commonly suggested hypotheses for hatching failure, such as unsuitable incubation conditions or infertility, are unlikely to explain all of the hatch rate variability in some populations and thus highlights an often overlooked conservation issue. This work was presented at a recent professional society meeting (14th Annual Symposium on the Conservation and Biology of Tortoises and Freshwater Turtles, New Orleans) and the manuscript is being prepared for submission to a peer-reviewed scientific journal.

Breann Ross will defend her M.S. thesis Comparison of mammal censuses via mark-recapture and camera traps in December 2016 under the supervision of Dr. Russell Burke. This project focused on the rapidly improving technology associated with wildlife camera trap surveys, and sought to compare this new approach to more traditional methods for censusing wildlife. She found that camera traps have severe limitations, especially where individuals of the target species cannot be uniquely identified in photographs. This work was presented at a two professional society meetings (2015 meeting of the Ecological Society of America, Baltimore and 21st Meeting of The Wildlife Society, Pittsburgh). Two manuscripts are being prepared for submission to peer-reviewed scientific journals.

b) Undergraduate Students:
This award also supported fourteen (14) independent research projects by undergraduate and high school students, many of whom have gone on to further success in science and engineering. Undergraduate students mentored by Dr. E. Christa Farmer and Dr. J Bret Bennington who worked on HUCCS projects included: Vanessa Ricigliano, (currently employed as a science technician at The Arizona Laserchron Center, University of Arizona and applying to graduate school), Steven Leone (currently applying to graduate school), Tamunoisoala LongJohn (currently a Ph.D. candidate in geosciences at Rice University), Courtney Melrose (earned an MS in geology from Stony Brook University), Emma Kast (currently a Ph.D. candidate in geosciences at Princeton University), Ashley Persaud (currently an environmental geologist at Roux Associates), Nika Chery (currently completing an MS in environmental geology at Brooklyn College), Emily Dorward (currently earning an MS in environmental science at U. Georgia), and Emily Weaver (currently earning an MS in geology at Syracuse University). Undergraduate student Adriana Eugene (set to graduate from Hofstra in 2017) worked with Dr. Russell Burke. Former undergraduate student Steven Miller, who worked with Dr. David Weissman, went on to a Ph.D. program at Princeton: http://news.hofstra.edu/2012/05/08/senior-receives-three-year-grant-from-national-science-foundation/. Many of these projects culminated in presentations at professional meetings (see list below).

c) High School Students:
Several high school students who participated in the Hofstra University Summer Science Program also worked on HUCCS research projects: Sheetal Tolia (Herricks HS), Benjamin Senzer (Syosset HS), Shira Polan (Syosset HS), Jacob Roday (Huntington HS), Marissa Labarca (Paul D. Schreiber HS), and John Finkbeiner (Paul D. Schreiber HS). All of these students presented their research in a poster session at the end of the summer.

3) Fostering Mentoring Relationships and Networking:
This award allowed two Hofstra faculty members, E. Christa Farmer and J Bret Bennington, to travel to Charlotte, NC for the annual meeting of the Geological Society of America in November 2012. Additional funds allowed four undergraduate research assistants Tamunoisoala LongJohn, Steven Leone, Ashley Persaud, and Emma Kast to attend the meeting as well. This travel nurtured mentoring relationships between faculty and students, and allowed students to network with other students and professionals.

4) Museum Exhibit:
The public outreach effort sustained by this award included the design, creation, and installation of an exhibit on climate change at the Cradle of Aviation Museum in Garden City, NY. All Hofstra University faculty who conducted research that was funded by this award (Dr. Myla Aronson, Dr. J Bret Bennington, Dr. Russel Burke, Dr. E. Christa Farmer, and Dr. David Weissman) participated in several brainstorming sessions with Museum personnel. These brainstorming sessions identified several viable exhibit ideas, which were subsequently developed in collaboration with Blumlein Associates, Inc. Exhibits were installed in two main stages in 2010 and 2012. The exhibit components are located just inside the main entrance to the museum, so all of the visitors to the museum have had a chance to see the exhibit. Museum staff report that approximately 1.5 million people have visited the museum since 2012, so this outreach has potentially been quite impactful.

Products that were enabled by this award include:

1. Bennington, J.B. and E.C. Farmer, eds. (2014) *Learning from the Impacts of Superstorm Sandy*. Elsevier (Academic Press), ISBN: 978-0-12-801652-7. Including:
    a. Chapter 1, J.B. Bennington and E.C. Farmer, "Introduction."
    b. Chapter 7, J.B. Bennington and E.C. Farmer, "Recognizing Past Storm Events in Sediment Cores Based On Comparison To Recent Overwash Sediments Deposited By Superstorm Sandy."
    c. Chapter 8, E.C. Farmer and J.B. Bennington, "Trace Metals as a Tool for Chronostratigraphy in Sediment Cores from South Shore Barrier Beach Marshes in Long Island, NY."
2. Koncki, N.G. and Aronson, M.F., 2015. Invasion Risk in a Warmer World: Modeling Range Expansion and Habitat Preferences of Three Nonnative Aquatic Invasive Plants. *Invasive Plant Science and Management*, 8(4), pp.436-449.
3. Conference presentations:
    a. Farmer, E. Christa; Browne, James; Peteet, Dorothy M.; Cochran, J Kirk; Heilbrun, Christina; Chery[#], Nika; LongJohn[#], Tamunoisoala; Mayo[#], Janel; Ricigliano[#], Vanessa. "Chronostratigraphy of a salt marsh sediment core from North Cinder Island in the Town of Hempstead, Long Island, NY, using radiocarbon and pollen" accepted to the American Geophysical Union 2016 Annual Meeting, San Francisco, CA.
    b. Weaver, Emily[#], Bennington, J Bret, and Harrison, Louise, 2016, Using sediment cores to investigate the history of a *Phragmites*-invaded coastal wetland on the shore of Long Island Sound in Queens, NY, *Geological Society of America, Abstracts with Programs*, 48 (2).
    c. Thomas J. Duchak and Russell L. Burke. The "Good" the "Bad" and the "Variable:" Hatch Rates in a Wood Turtle (Glyptemys insculpta) Population are influenced by Maternal Identity as much as Random Environmental Factors. 14th Annual Symposium on the

Conservation and Biology of Tortoises and Freshwater Turtles, New Orleans, August 1 — 4, 2016.

d. Breann Ross, Russell L. Burke, Lorenza Beati, Howard S. Ginsberg, Graham Hickling, Nicholas H. Ogden, Jean I. Tsao. Evaluation of camera trapping as a method for estimating raccoon (Procyon lotor) and opossum (Didelphis virginiana) densities. 100th Annual Ecological Society of America, Baltimore, MD, August 09 - 14, 2015.
e. Breann Ross, Russell L. Burke, Lorenza Beati, Howard S. Ginsberg, Graham Hickling, Nicholas H. Ogden, Jean I. Tsao. Evaluation of camera trapping as a method for estimating raccoon (Procyon lotor) and opossum (Didelphis virginiana) densities.
f. Fernandes, V.[#]; Farmer, E.C.; Browne, J.; Peteet, D.; Mayo, J.[#]; 2015. "The Environmental History of North Cinder Island Marsh in the Town of Hempstead, New York." Long Island Geologists' 22nd Conference on Geology of Long Island and Metropolitan New York. http://www.geo.sunysb.edu/lig/Conferences/abstracts15/4-15-program.htm
g. Bennington, Gail K. and Bennington, J Bret, 2014. Recruiting pre-service teachers as mentors in a university summer science research program to better engage high school students in geoscience research*, Geological Society of America, Abstracts with Programs*, 46 (6): 386.
h. Farmer, E. Christa; Bennington, J Bret; Leone, Steven[#]; Longjohn, Tamunoisoala[#]; Persaud, Ashley[#]; Chery, Nika[#]; Spero, Dayna[#]; Kast, Emma[#]; and Melrose, Courtney[#]; 2013. "Trace Metals as a Tool for Chronostratigraphy in Sediment Cores from South Shore Barrier Beach Marshes in Long Island, NY." Geological Society of America *Abstracts with Programs.* Vol. 45, No. 7, p.53.
i. Bennington, J Bret; Farmer, E. Christa; Chery, Nika[#]; Dorward, Emily[#]; Leone, Steven[#]; Persaud, Ashley[#]; and Spero, Dayna[#]; 2013. "Recognizing Past Storm Events Recorded in Sediment Cores Based on Analysis of Recent Overwash Lobes Deposited by Superstorm Sandy." Geological Society of America *Abstracts with Programs*. Vol. 45, No. 7, p.52
j. Farmer, E.C., JB. Bennington, C. Melrose[#], E. Kast[#], S. Leone[#], T. LongJohn[#], A. Persaud[#], 2012. "Identifying Hurricane Overwash In Sediment Cores from the Great South Bay, New York." Geological Society of America *Abstracts with Programs.* Vol. 44, No. 7, p.87.
k. Farmer, E.C., JB. Bennington, C. Melrose[#], M. Jensen[#], A. Hoffmann[#], T. Longjohn[#], and L. Noboa[#]. "Developing a Chronostratigraphy for Sediment Cores from Gilgo Beach Marsh, Long Island, NY." Long Island Geologists Eighteenth Conference, April 9, 2011.