Understanding the Clouds

When Luz Padró arrived at Georgia Tech as a chemical engineering graduate student, she never imagined that her research would lead her to Mexico City to study one of the world's most populated and polluted cities.

The scope of chemical engineering research continually expands, reaching beyond traditional core areas such as petroleum, plastics, and paper. Many of the emerging concentration areas are expected, including biomaterials and alternative fuel cells, while others are somewhat surprising.

Although environmental projects exploring carbon capture, water purification, and biofuel alternatives are already hot topics in chemical engineering research, reducing air pollution and predicting climate change are areas that are somewhat nontraditional. Solving these environmental challenges has been on the forefront of atmospheric science research for many years. Investigators have learned the benefit of applying models and process systems methods developed by chemical engineers to their work. The precision of investigative equipment now allows researchers to examine the individual chemical components that make up atmospheric aerosols (i.e., suspended particulate matter) and improve air quality and climate models.

After arriving on the Georgia Tech campus as a 2004 graduate of Virginia Tech's chemical engineering program, PhD candidate **Luz Padró** was immediately intrigued by the cloud studies under investigation in Dr. **Athanasios Nenes**'s lab. "I chose Georgia Tech because its program offered so many different professors conducting a variety of research," Luz says. "I liked the fact that I had a lot of different opportunities."

Although Luz's undergraduate research consisted of biomedical topics, including protein kinetic experiments with surface plasmon resonance (SPR) to investigate the kinetics of ligand binding reactions, the switch to environmental projects was an easy decision.

"I thought it would be interesting to learn how our practices affect the ecosystem and where we live so that we can all get a better understanding of what we need to do as a culture to make a significant change," she says.

The recipient of several honors, including a NASA Earth System Science Fellowship, a Goizueta Foundation Fellowship, and an AIChE Women's Initiatives Committee grant, Luz is a native of Puerto Rico, where her parents and siblings currently reside. She will graduate in spring 2009, after completing two field campaigns, including working on the ongoing Megacities Impact on Regional and Global Environment (MIRAGE)-Mex field campaign in March 2006 *(mirage-mex.acd.ucar.edu/index.shtml)*, a project that examines the chemical and physical transformations of atmospheric constituents (gases and aerosols) in the polluted Mexico City outflow.

The MIRAGE-Mex project coordinates and integrates observations from ground stations, aircraft, and satellites, and provides a rich database for improving regional and global models of the transport and transformations of aging urban pollutants. Because the atmosphere is a complex, dynamic, and fragile system, it is essential for scientists to accurately understand and predict the global effects of air pollution, especially on climate change and stratospheric ozone depletion. Organized by The National Center for Atmospheric Research-Atmospheric Chemistry Division (NCAR-ACD), MIRAGE-Mex is part of the Megacity Initiative: Local and Global Research Observations

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(MILAGRO), a larger set of coordinated field campaigns that together enable investigation of megacity outflow chemistry on a variety of scales *(www.eol.ucar.edu/projects/milagro)*.

"Working on such an environmentally significant project was an incredible experience," says Luz. "I spent one month in Mexico City and I never saw the horizon because the scattering light around the mountains traps the pollution and makes it constantly hazy." After experiencing the profound pollution firsthand, Luz felt a personal connection to her work. "Living in that environment every day is not a pleasant experience," she says. "It was exciting for me to know that my research may one day help provide solutions to the improvement of the air quality."

While in Mexico City and the immediate surrounding area, Luz collected aerosol samples on filters using an instrument called a Hi Vol. The samples consisted of particulate matter that is less than 2.5 microns, small enough to breathe and potentially dangerous to human health. The filters were white when placed on the Hi Vol but after twelve hours of collection, the filters turned dark gray, clearly indicating the severity of polluted matter. Luz stored the samples in a freezer and then brought them back to her Georgia Tech lab for analysis.

Luz analyzed samples from the communities immediately outside of Mexico City to determine how atmospheric conditions are impacting the spread of pollution. Luz says that "Air pollution doesn't stay in one place – winds and weather play an important part in the transport of pollution and it affects everything it comes in contact with."

Unlike greenhouse gases, which warm the climate, clouds can have the opposite effect and cool the climate by reducing the amount of solar radiation that reaches the Earth. It is currently thought that aerosols cool through their interactions with clouds and are one of the largest sources of uncertainty in climate model predictions of anthropogenic climate change. Aerosols affect clouds by acting as the seed for droplet (or ice crystal) formation. Pollution tends to increase the number of seeds; hence, polluted clouds tend to have more droplets than their pristine counterparts. As a result, there is more surface area for sunlight to reflect upon; the droplets also tend to be smaller and may lead to clouds that are less efficient in producing rain. To predict how many cloud droplets will form in a polluted air mass, one needs to know the particle size distribution and chemical composition of the particles. The latter is quite a challenge for models, since a large fraction of particle mass (up to 70%) is composed of a "soup" of organic compounds. "We already know how inorganic matter affects cloud formation, but we need to develop a better understanding of the organics present in aerosols," says Luz. Most of Luz's research focuses on characterizing the organic-water interactions important for formation of cloud droplets by analyzing the water uptake and cloud condensation nuclei (CCN) activity of atmospheric aerosols captured from densely polluted areas. By comparing these data against clean regions and laboratory-generated particles, Luz is unraveling the properties of this mysterious mixture and their role in aerosol-cloud interactions.

"We need to reduce the uncertainty of how much clouds cool the Earth so that we can make more accurate predictions of global change," says Luz. "We still need to develop methods to better understand the kinetics of droplet formation, especially the potential slowing of it from the presence of organic surfactants."

Now that Luz has made her contribution to the problems facing the future of the global climate, she is considering taking her research on aerosols in a new direction while building on her undergraduate foundation in the area of biomedicine. "I am considering exploring the possibility of using aerosols as a method of drug delivery," she says. "Also, I have a strong personal desire to investigate the effects of aerosols on health degradation."

Regardless of where the future may lead, Luz knows that her long-term goals include obtaining an academic appointment at a teaching-oriented institution. Another element of her future has already been determined. On January 2, she married Roel Sigifredo Sanchez-Carrera, who is a recent PhD graduate of Georgia Tech's School of Chemistry and Biochemistry. The couple is searching for a location where they both can pursue their professional careers. In the meantime, Luz says that she is looking forward to completing her thesis and enjoying a little downtime. "I love watching *CSI* and *Without a Trace* and reading crime and suspense novels," she says. The past five years of intense research and travel have left little opportunity for that luxury, and Luz plans to indulge herself a little before tackling her next research challenge.

Global Learning

Garry Betty, '79, President and CEO of EarthLink, Inc. was one of ChBE's most accomplished alumni when he passed away in January 2007. His legacy inspires others through the Garry Betty Scholarship for International Studies. ChBE established the scholarship after Garry's death to commemorate his passion for adventure and to encourage others to pursue study abroad opportunities.

Jessica Swearengen, a ChBE senior, is the 2008 recipient of the scholarship. "When applying for the award, I had the opportunity to learn about Mr. Betty and the tremendous impact he had on this world. It is an honor to be a Garry Betty Scholar," says Jessica.

The scholarship supported Jessica's studies at the Imperial College of London this past summer. ChBE has participated in a summer program in London for more than 30 years. Participation is limited to a total of 25 students who have completed prerequisites for the unit operations laboratory course. In addition to receiving six credit hours, the four-week program includes opportunities for students to participate in cultural events and sightseeing.

"The program really changed my career outlook. I had never been outside of the U.S. before this trip. Going to Europe changed my perspective. I am now considering positions in and out of the country," shares Jessica. "I would encourage other students to seek out international learning opportunities, and I am grateful for the scholarship support I received to make this trip a reality for me."

To learn more about supporting ChBE students through scholarships, please contact Melisa Baldwin at 404.894.0987 or melisa.baldwin@chbe.gatech.edu.