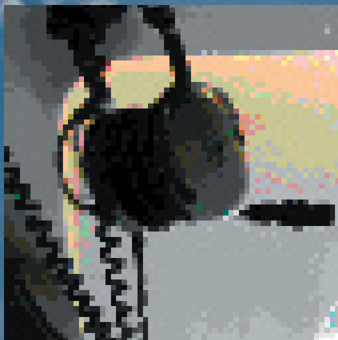


AIR H

In the largest pollution study ever, more than a dozen UNH scientists are trying to understand the air we breathe

Like all the other passengers, I board the jet with no ticket, no luggage and no destination. Oddly enough, this is no problem, even in the edgy, post-9/11 world, for this is no ordinary airplane.

We are in the National Aeronautic and Space Administration's DC-8 science aircraft, a 1966 commercial jet that has been converted into one of the world's most sophisticated flying laboratories. It's used for scientific studies ranging from archaeology to volcanology, but today's mission is to study the air around us.

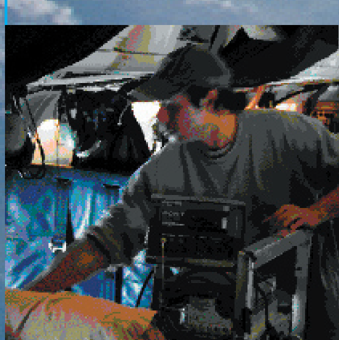
Our flight, taking off from Pease International Tradeport in coastal New Hampshire, is one part of a six-week-long air quality study involving hundreds of scientists from around the world, including 20 researchers and 18 undergraduate and graduate students from UNH. The project—known as the International Consortium for Atmospheric Transport and Transformation, or ICARTT—is the largest air quality and climate study ever conducted. It seeks to better understand how pollution moves and changes as it makes its way across the North American continent, mixes and morphs in the coastal marine boundary layer, and then heads toward Europe.

Over the next eight hours, the DC-8 will make one gigantic loop down the East Coast to South Carolina, veering right towards Tennessee and Kentucky and heading into the monotonously flat checkerboard of Middle America. Somewhere over Illinois we will come about, nose into the Rust Belt and make for home. Along the way, the plane will buzz fishing vessels and farmers from a mere 1,000 feet, the four big jet engines bouncing up and down in gentle turbulence, silhouetted uncomfortably near the landscape below for 20 minutes at a time. It's like being on a perpetual runway approach and, as a result, tends to generate panicky phone calls from citizens alerting authorities that a commercial jet is about to crash. On occasion, the plane will fly as low as 300 feet to sample pollutants. Traveling at 335 miles per hour at such low altitudes requires keen eyes to scan for small, slow-moving airplanes.

While the project's particular focus is New England, air pollution observes no boundaries, says Berrien Moore III, director of UNH's Institute for the Study of Earth, Oceans and Space. "Air pollution is truly global in nature," he says. "What happens in Beijing will affect Boston, and vice versa." Earth-related science is moving from splintered, myopic, discipline-specific investigations, he says, toward a more comprehensive, interconnected, systems-based approach. Science, these days, ponders the big picture.

Because pollution created elsewhere often ends up here, New England is ignominiously referred to as the "nation's tailpipe." The dynamics of this pollution, its source and the mechanisms that transform and redistribute it are ICARTT's major goals. The study will also set the stage for regular air quality forecasts by the National Oceanic and Atmospheric Administration.

At the heart of the study are the complex, computer-based mathematical models used to predict air quality based on emissions data, meteorology, chemistry



OUTER PHOTOGRAPHS COURTESY OF DAVID SIMS

EADS

By David Sims '81

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Scenes aboard NASA's DC-8 jet, far right, one of the world's most sophisticated flying laboratories. The R/V Ronald Brown's Doppler radar, near right, underneath a Portsmouth, N.H., summer sky.

PERRY SMITH/UNH PHOTOGRAPHIC SERVICES [2]

and other factors. Researchers crank out predictions on a daily basis; others then probe the skies to verify or disprove the predictions. This is what grows the science.

Among other things, scientists are looking at what happens, chemically and physically, during the night—what senior scientist Fred Fehsenfeld with NOAA's Aeronomy Laboratory in Boulder, Colo., refers to as "the dark side of the force."

In addition, the scientists are gauging the impact of dust particles from Asian storms or forest fires in Alaska and Canada on the absorption of sunlight. They are looking at the pollutants from the smokestacks of coal-fired plants in the eastern United States and urban pollution from the entire Eastern Seaboard. They are measuring "biogenic," or natural emissions of hydrocarbons from the region's forests, and analyzing the influence that the coastal marine environment has on transforming pollutants. All of this has an impact on the quality of New England's air and, in turn, the air we export across the sea to Europe and beyond. It's a small world after all.

To conduct the massive, and massively complex, project, there is a long list of hardware: 12 aircraft, including British, French, German and Canadian planes; NOAA's P-3 "Hurricane Hunter" turboprop aircraft and its 274-foot-long Research Vessel Ronald H. Brown; four 12-pound, 10-foot "smart" balloons; three satellites and a number of ground-based air monitoring sites, including UNH's four state-of-the-art air quality observatories strategically located around the state.

And the DC-8. After a quick tour down the aisle, NASA mission manager Chris Jennison has me watch a pre-flight safety video so I'll know what to do in an emergency. Unlike the easy-to-ignore safety messages on commercial aircraft, this video is designed to get your full attention.

As it turns out, the plane has my attention already. I am surrounded by some two dozen state-of-the-art experimental contraptions, bolted to the floor, that are wheezing, popping, clicking, purring and off-gassing. Jennison mentions that all the instruments are hand made to measure air pollution down to parts per quadrillion, and consequently use fairly exotic materials. Nitric oxide, for example, is "amazingly toxic" and can combine with oxygen in the blood to cause suffocation. (All chemicals are double-contained and well vented, he assures me.) Jennison also points out the "extremely powerful" lasers on board, which require close coordination with the Federal Aviation Administration and, at times, even the North American Air Defense Command. With a laser zapping the atmosphere to measure ozone and aerosols up to 20 kilometers away, mission managers must be ever vigilant that other aircraft or satellites don't get inadvertently fried.

Much of the exotic scientific gadgetry stuffed into the plane looks as if Thomas Edison and Rube Goldberg put their heads together. Plastic tubing of all sizes and colors snakes down the fuselage, venting chemicals or delivering air to instruments. Windows have been popped out and replaced with metal plates perforated with a hodgepodge of air sampling inlets.

I feel as if I'm looking at time travel engineering, except for the menagerie of stuffed mascots and signs. A rubber chicken hangs in a noose with a placard reading, "Sacred offering for stable CO, N_20, CH_4." Another sign reads, "Yararrgh! Here be monsters of tha deep! Ye've been warned! —Aerosol Pirates."

After bumping along in low-level turbulence, we climb to 40,000 feet, level off and begin to spiral slowly downward in a six-mile-wide circle while NASA's Terra satellite passes over the same air space high above. This is the process of "truthing" the satellite: making the same measurements on board both craft and comparing the results in an effort to gauge the satellite's accuracy. This process will occur many times over the course of the project.

Some of the components of pollution being studied include ozone (smog), carbon monoxide and dioxide, nitric oxide, total reactive nitrogen, sulfur dioxide, formaldehyde, acetylene and perchloroethylene. All of these compounds are considered bad for people or the environment, or both: perchloroethylene, for example, comes primarily from dry cleaning fluid and has been linked to cancer and liver and kidney disease. Air pollution contributes to some 60,000 deaths a year in the United States, estimates Cameron Wake '93G, research associate professor with the Climate Change Research Center.

Sitting before a rack of instruments and computer screens, CCRC research project engineer Eric Scheuer '92 is measuring atmospheric gaseous nitric acid, a by-product of the nitrogen oxides emitted by car and truck engines. It's one of the primary ways nitrogen compounds, which can lead to ozone and acid rain, get transported long distances. Digital numbers flash up and down in response to changes in air temperature, density and water vapor. Using the tip of his sneaker, Scheuer makes delicate adjustments to the intake flow rate of his instrument, a UNH-built mist chamber-ion chromatograph.

While Scheuer is able to sit comfortably and toe-tap his instrument into shape ("It's a lot easier than bending down," he says), there is no rest for his colleague Jack Dibb, a CCRC research associate professor of earth sciences. Dibb is standing behind the nitric acid instrument, measuring aerosols. Wearing latex gloves, Dibb changes out filters every five minutes from hefty white plastic pipes. He places each one in a plastic bag and heat seals and labels it. These will go back to UNH for analysis.

UNH's prominent role in the project was due in part to the university's air monitoring observatories, which sample the atmosphere day and night for some 180 chemicals. Among the most sophisticated in the world, they provide a long-term record to put into context the snapshots of air quality gathered by the study's mobile platforms. The observatories, built with AIRMAP funds (Atmospheric Investigation, Regional Modeling, Analysis and Prediction) secured with the help of Senator Judd Gregg (R-N.H.), are located atop Mt. Washington, in Moultonborough, on Appledore Island at the Isles of Shoals, and at Thompson Farm off Packers Falls Road in Durham, just a few minutes from the UNH campus.

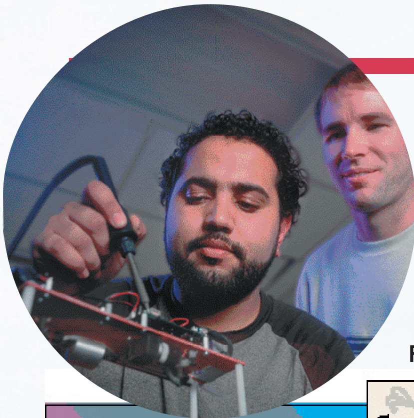
The Thompson Farm observatory is, in fact, sometimes referred to as a NASA DC-8 without wings because its instrumentation can do the atmospheric equivalent of finding a needle in a haystack. The list of chemicals measured is a yard long and contains such beauties as trans-4-methyl-2-pentene and chlorodibromomethane.

During the campaign, Shannon Buckley, a UNH junior with a dual major in environmental conservation and international affairs, monitored the Thompson Farm instruments and collected data. If something went wrong with an instrument or if the numbers didn't look right, it was Buckley's task to try to figure it out. "Hands-on learning, I find, is the easiest way to learn, and that is exactly what I've gotten this summer," says Buckley. "People I talk to are surprised that undergraduates at UNH have these research opportunities available to them, but the undergraduate involvement at EOS has been amazing."

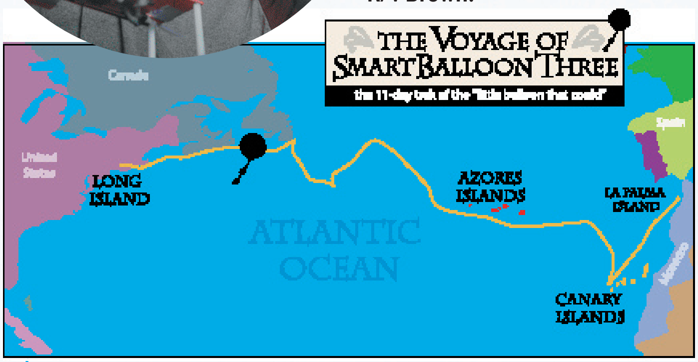
About 20 miles away on Appledore Island, a 63-foot concrete tower constructed during World War II to spot enemy ships was transformed into a state-of-the-art atmospheric chemistry lab with lasers, gas chromatographs, mass spectrometers and other exotic instrumentation. A long-time site for marine research, Appledore now has enhanced research capabilities as a result of the project.

Launching a balloon from the R/V Brown, left; Sallie Whitlow, UNH lab supervisor, lower left; Alex Pszenny, UNH research associate professor of atmospheric chemistry, lower right, with instruments on Appledore Island.

LISA NUGENT/UNH PHOTOGRAPHIC SERVICES [3]



Mechanical engineering major Naoufal Souitat, left, and research technician Sean Wadsworth '95 work on an ozone detector similar to one carried by a "smart" balloon across the Atlantic. Below, the R/V Brown.



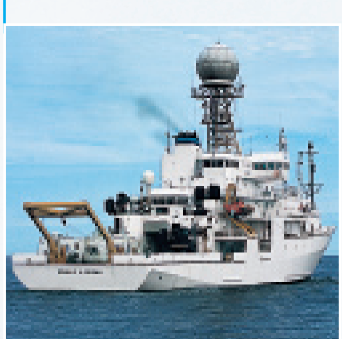
Aboard the R/V Brown, the largest vessel in the NOAA fleet and the only naval vessel equipped with a state-of-the-art Doppler radar system, UNH laboratory supervisor Sallie Whitlow collected nitric acid data. The ship measured coastal pollution levels from New York City to Maine for several weeks in July.

Meanwhile, four NOAA smart balloons—so called because their double-shell design allows researchers to control their altitude—were launched by UNH's Targeted Wind Sensing program from Long Island, N.Y. The hope was they would catch an air current up the East Coast and across the Atlantic Ocean. Each balloon carried a small, one-of-a-kind ozone detection instrument developed at UNH.

While there are mind-numbing difficulties to overcome when collecting samples from a jet as it hurtles through the air, measurements made from a balloon as it lazily bobs along at five meters per second are a relative piece of cake.

Says atmospheric chemist Robert Talbot, AIRMAP and CCRC director and the principal investigator for the program, "In the jet, you pass through so much air so quickly that you really can't understand the kind of minute, complex chemistry that could be occurring in that location."

The successful balloon flights have opened up a new era in atmospheric research, Talbot says: "This is really the first time we've been able to put instruments in an air mass and let it drift with the current." And comparatively, the balloon missions come cheap. Unlike research aircraft, which can cost a quarter of a million dollars a day to fly and whose flights typically last only eight to nine hours, smart balloons don't need to land, can make measurements 24 hours a day and can carry miniaturized, research-grade instruments that are relatively cheap and disposable. The balloons' ozone detector, developed at UNH, cost just $1,000, a bargain compared to the $15,000 that full-sized detectors typically cost.



The project's researchers got the biggest bang for their buck with smart balloon number three, which, after a meandering, 11-day trek across the Atlantic Ocean, headed towards the North African country of Morocco. The intrepid dirigible, dubbed "the little balloon that could," not only exceeded all endurance expectations but measured ozone levels over the North Atlantic of 195 parts per billion—more than twice the Environmental Protection Agency's standard. What this indicates, according to Talbot, is that there's a lot more ozone being exported from North America than previously thought.

In addition to its scientific prowess, the balloon provided a few days of high drama for UNH scientists in Durham and a UNH student from Morocco. Junior mechanical engineering major Naoufal Souitat, who helped build the balloon's ozone detector, just happened to be at home on vacation as the balloon drifted towards foreign air space and, potentially, a politically dicey situation. A rescue mission began to form.

Phone calls were placed to embassies in Morocco and Washington, D.C. A flurry of e-mail messages and cell phone calls between scientists and engineers ensued. Letters were fired off to officials in Morocco—who wanted to know what the balloon carried—reassuring them that there were no explosives or photographic equipment aboard.

To avoid a possible international incident, researchers decided to bring the balloon down on the island of La Palma in the Canary Islands. Souitat was poised to recover the scientific instrument package. He recalls, "I was just sitting, waiting for the phone call." The call finally did come, but it was not what he wanted to hear: the recovery had been aborted.

During its descent to La Palma, the balloon apparently rammed into the craggy, volcanic mountainside, popping its Kevlar-like outer shell. With only its helium-filled inner bladder intact, it took off like an escaped circus balloon and rose to 11,000 feet.

Although the ultimate fate of the balloon remains unknown, Souitat and other undergraduates will have similar opportunities for scientific adventure in the future. EOS research project engineer Don Troop '02, research technician Sean Wadsworth '95, Souitat and others are currently at work re-engineering big, bulky instruments weighing many pounds into compact packages of tiny tubes and microchips weighing just ounces. On future balloon missions, these devices will float through the air with the greatest of ease, measuring levels of atmospheric carbon dioxide and the size and composition of aerosols or particles.

The aerosol pirates, the creators of intrepid little balloons, the toe-tapping and needle-hunting researchers—all hope to strengthen our ability to dissect and forecast air pollution. When it comes to the atmosphere, what goes around comes around, quite literally. Ultimately, this ambitious study of the skies over New England could lead to cleaner skies around the world and a more healthful environment for everyone on Earth. ~

David Sims is the science writer at EOS. He graduated from UNH in 1981 with a B.S. degree in environmental conservation.

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MAP BY BRIDGET FINNEGAN