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TALL TOWERS The 984-foot tower, left, and the view from atop the tower. Credit Kevin Moloney for The New York Times

**ENVIRONMENT**

# Carbon Detectives Are Tracking Gases in Colorado

By SUSAN MORAN DEC. 1, 2008

BOULDER, Colo. — As she squeezed herself into a telephone-booth-size elevator to ascend a 984-foot tower in Colorado's eastern plains, Arlyn Andrews said with a grin, "This makes me want to go rock climbing."

It's a good thing she loves climbing tall structures. Dr. Andrews, an atmospheric scientist at the National Oceanic and Atmospheric Administration in Boulder, climbs the tower periodically to make sure the narrow tubes running from the tower to analyzers nearby are properly taking continuous samples of carbon dioxide, methane and a cocktail of other greenhouse gases.

The elevator grumbled to a halt about five minutes later at an 820-foot perch, where the tower's slender shadow stretched into a neighboring sunflower field in the early morning sunlight. "We're able to detect the whole mix of emissions here — what comes from automobile traffic, from industry, from residential development and from agriculture," Dr. Andrews said.

She is one of many carbon sleuths, scientists who track and analyze where greenhouse gases come from and where they go over time. Think of it like personal finances. To plan for a sound financial future, it helps to create a budget and keep track of how one is spending money. Similarly, atmospheric scientists need to develop a “budget” for greenhouse gases.

But the atmosphere delivers no monthly statement on greenhouse gas dynamics, so scientists have to tease out the information from disparate and often contradictory sources. The key task is measuring the sources, or emissions, of these planet-warming gases, and the “sinks” — forests, cropland and oceans that absorb carbon. This budget can then inform intelligent climate-control policy, whether it be managing one forest or shaping national emissions regulations.

The quest to track carbon began 50 years ago when an atmospheric scientist, David Keeling, cranked up an analyzer and started running the world’s first carbon dioxide-measuring observatory, at Mauna Loa, Hawaii. Now, thanks to an expanding combination of atmospheric and land-based measuring techniques, scientists can quantify more precisely the sources and sinks of $CO_2$. They also better understand how heat-trapping gases vary over time and space, not just globally but on continental and even regional scales.

By applying the various methods and checking them against each other and against computer models, scientists are also more accurately distinguishing certain human-caused greenhouse gases from those that stem from natural fluctuations in terrestrial and ocean ecosystems.

The stakes are much higher now than they were 50 years ago. Globally, carbon sinks are being outpaced by rising emissions. Atmospheric instruments like the NOAA-financed network of eight tall towers offer climate scientists a window into processes that control greenhouse gas emissions and sinks.

But uncertainty remains high — often as high as estimates themselves. For instance, researchers think about half of the $CO_2$ emitted into the atmosphere gets absorbed by oceans and land, but they do not know precisely where the gases come from and where they end up. This knowledge gap has serious policy implications; until it becomes clear where emissions are going, it will remain difficult to have verifiable credits for sequestering carbon.

“We need to make sure that carbon markets are affecting climate change, not just putting money in the hands of some companies and people,” said Lisa Dilling, an assistant professor of environmental science at the University of Colorado, Boulder.

A vexing challenge is that surface inventory assessments — based on measuring forests, agricultural fields and smokestack emissions, for instance — generally do not agree with atmospheric measurements.

“We’ve got to close the carbon budget to know precisely what’s going where,” said Kevin Gurney, an assistant professor of earth and atmospheric sciences at Purdue University in Indiana.

Toward that goal, last April, Dr. Gurney started the Vulcan Project. Named after the Roman god of fire, Vulcan is a massive database and a graphic map that shows hourly changes of $CO_2$ emissions from the burning of fossil fuels in every locale by every source, including vehicles, power plants and factories.

Another carbon budget-mapping tool for atmospheric scientists is called CarbonTracker, a data analysis system begun last year by Pieter Tans, a senior scientist at NOAA’s Earth Systems Research Laboratory and his colleagues at NOAA. The online system shows how $CO_2$ ebbs and flows across continents and how that varies year to year.

Dr. Tans started the tall tower network in 1992. He hopes to expand it to 30 structures from the current eight. The most advanced instruments were introduced last year in California — one in San Francisco and the other in the San Joaquin Valley, near Sacramento.

This summer, a continuing study at a tall tower located on corn and soybean fields in West Branch, Iowa, revealed that the crops sucked a surprisingly large amount of $CO_2$ out of the atmosphere during the summer growing season — as much as 55 parts per million out of a background $CO_2$-equivalent level of 380 parts per million.

Any farmer knows that corn grows fast and soaks up lots of carbon in the process, and later respires $CO_2$ when it is harvested or left to decay. But this was the first time that scientists detected such a large reduction of $CO_2$ inventory over a specific region during growing season. The study also showed a large drop in $CO_2$ concentration from the previous summer, probably because floods delayed the growing season this year, Dr. Andrews said.

The network of tall towers has drastically improved on air samples taken from small airplanes. And the towers cover a broader area than shorter, land-based instruments like so-called flux towers that measure how many tons of $CO_2$ flow in and out of a specific plot of land, roughly within a square kilometer.

In January, the next frontier of atmospheric $CO_2$ measuring instruments will begin when the National Aeronautics and Space Administration launches the first carbon-scanning satellite, called the Orbiting Carbon Observatory.

Each day, the satellite will orbit Earth 15 times, taking nearly 500,000 measurements of the "fingerprint" that $CO_2$ leaves in the air between the satellite and Earth's surface. The data will be used to create a map of $CO_2$ concentrations that will help scientists determine precisely where the sources and sinks are — showing differences in trace gases down to a 1 part per million precision against a background of 380 parts per million $CO_2$ equivalent.

Ultimately, many scientists hope their discoveries will inform climate policies, like mandatory limits on emissions that many expect Congress will eventually impose.

"It's a national priority to understand the carbon budget so people can make smart, good policy," said Dr. Gurney of Purdue, adding that many scientists feel pressured to push the boundaries of knowledge in this field in their effort to slow global warming. "It's what motivates us to wake up in the morning."

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