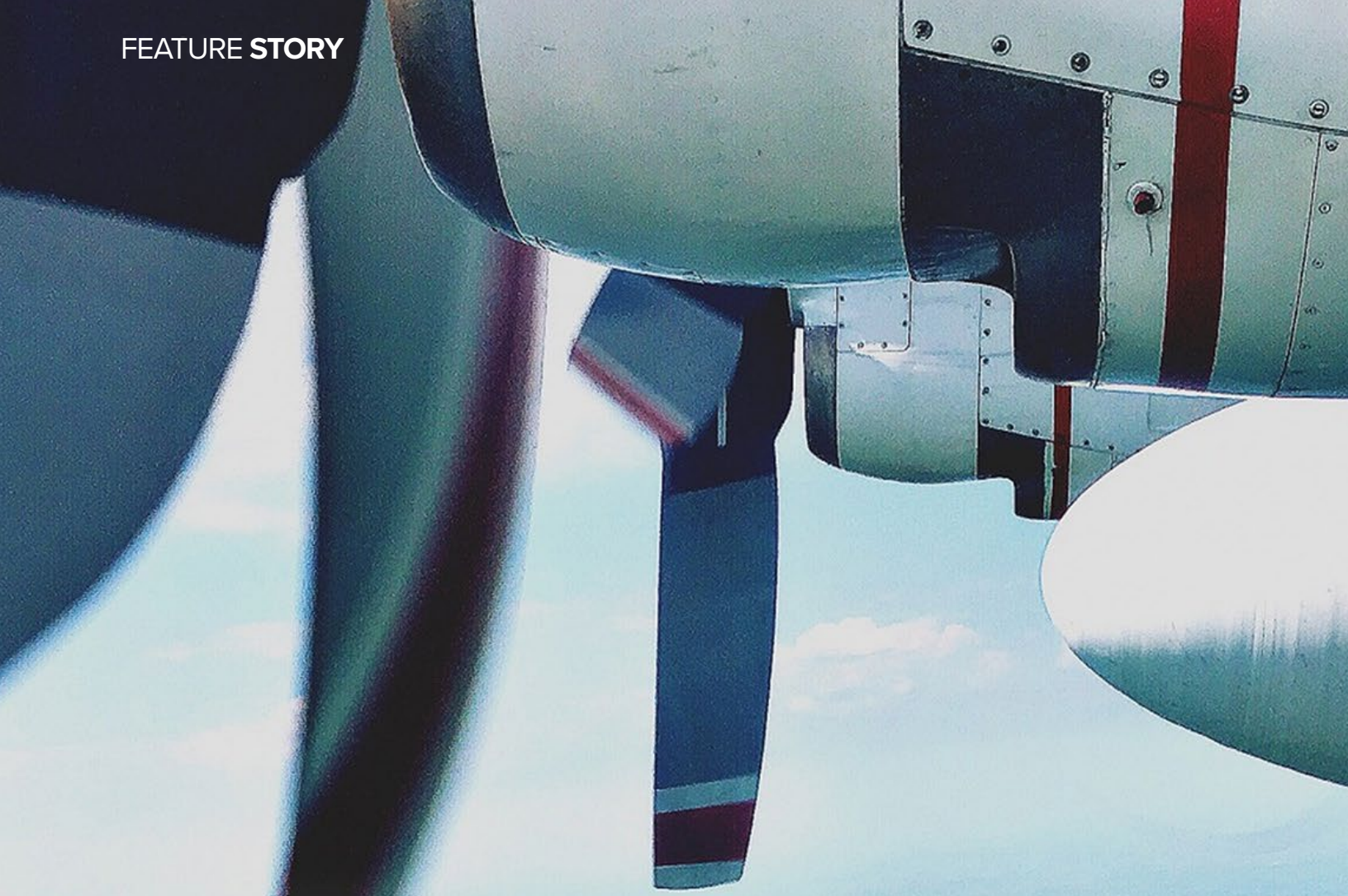


TO THE AIR FOR ANSWERS

SIX-YEAR ACT-AMERICA CAMPAIGN TAKES TO THE SKIES, LANDS WITH NEW DATA FOR UNDERSTANDING THE CLIMATE SYSTEM

Photo: Joe Atkinson, NASA

by David Kubarek

As researchers tick off the list of accomplishments culminating from the past six years of the $30 million Atmospheric Carbon and Transport–America (ACT-America) research endeavor, they see the results not as soundbites or Hollywood-infused eureka moments in science, but as a carefully orchestrated campaign of more than one hundred experts working for years towards common goals to solve complex problems.

Some of their discoveries will long impact how we aid the management of greenhouse gases by improving our tools for auditing greenhouse gas sources and sinks: Researchers wrote the book on how greenhouse gases are moved by weather systems, laid the groundwork for advancing regional diagnoses of greenhouse gas sources and sinks, confirmed the accuracy of NASA's Orbiting Carbon Observatory-2, and flagged methane emissions estimates in the United States to be far too low.

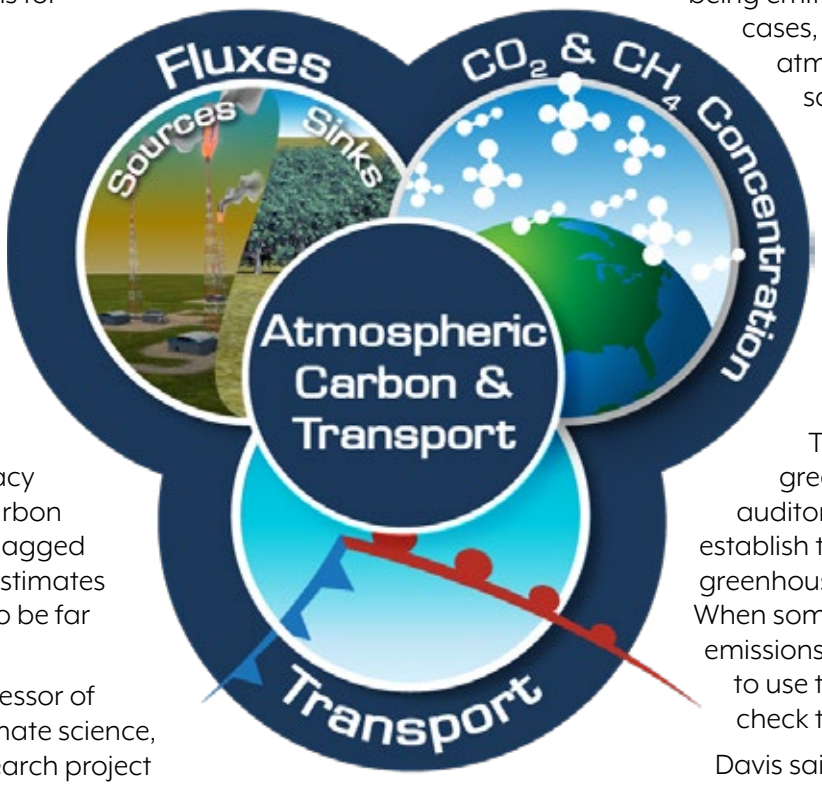
For Ken Davis, professor of atmospheric and climate science, the decade-long research project began with a quest to understand what role weather plays in moving greenhouse gases through the atmosphere. To a researcher, it's an unanswered question but one that has global implications.

As global leaders recently met at the United Nations Climate Change Conference, much of the focus was on curbing greenhouse gas emissions and finding fair and equitable ways of measuring those emissions by nation.

Fields of green are an ever-present sight on the Aug.4, 2016 science flight, which nips down into Missouri before heading back up through Nebraska and into southern South Dakota, to measure carbon dioxide and methane around both sides of the front in NASA's C-130 Hercules research aircraft.

But little is known about the role weather plays in distributing these emissions. Understanding that, Davis said, will strengthen our existing methods for measuring greenhouse gas emissions. Atmospheric data captured in the ACT-America campaign could one day be used to better estimate greenhouse gas sources and sinks, leading to better monitoring and management of regional and global greenhouse gas emissions.

"We know with great accuracy the global trends in greenhouse gases, but we often don't know exactly where or how much these gases are being emitted into, or in some cases, removed from the atmosphere," Davis said. "Because of this uncertainty, there's a lot of interest in using atmospheric concentration measurements to find out precisely where these greenhouse gases are originating. Think of us as the greenhouse gas auditors. We're helping to establish the role of regional greenhouse gas auditors. When someone reports emissions, we want to be able to use the atmosphere to check their figures."



Davis said this improved auditing will also be used to improve existing models of greenhouse gas emissions and sinks. These models are needed to predict future climate scenarios.

ACT-America is born

NASA accepted Davis' proposal on his second try, said Mike Obland, mission manager at NASA's Earth System Science Pathfinder Program Office and former project manager for ACT-America. Obland suspects some of the measurement technology wasn't quite ripe the first time around.

Obland worked with Davis to pull off one of five Earth Venture Suborbital-2 missions—the biggest non-space-based project of his career—which resulted in three years of domestic flights merged

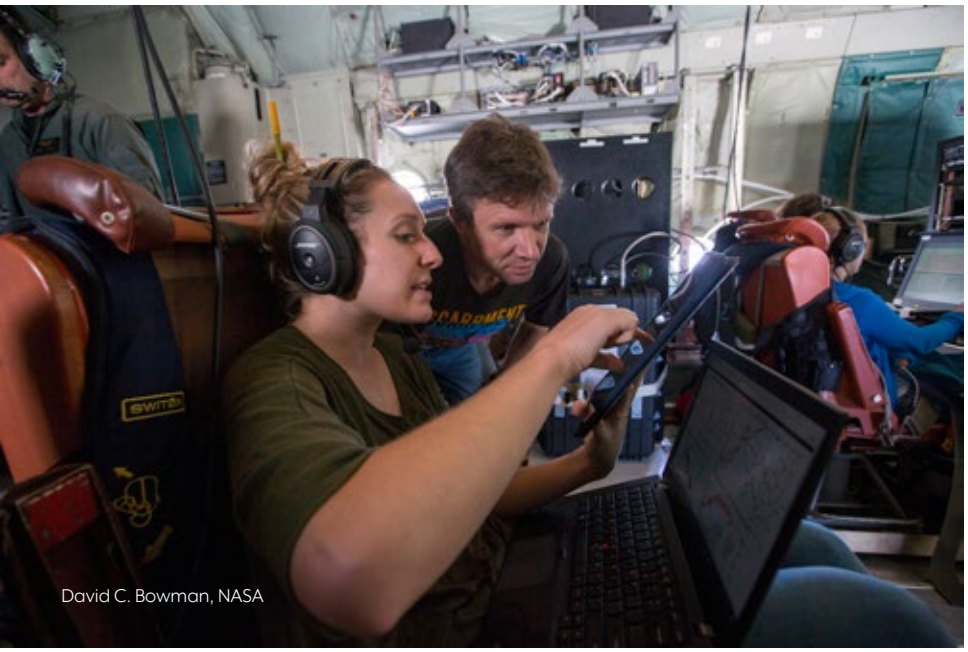
with a growing portfolio of research results. The first year of the project was spent instrumenting the two research aircraft—a Lockheed C-130 Hercules and Beechcraft Air King B200 —and the final eighteen months were entirely devoted to research using the data collected by the flights.

The team logged over 1,100 flight hours with takeoffs from three points in the United States, often using the planes in coordinated flight patterns at multiple altitudes sampling weather systems or flying directly underneath space-based satellites. Researchers said it was important to gather flight data from different seasons and years to capture a general understanding of conditions over the central and eastern United States. The resulting data, the first airborne record of how greenhouse gases are distributed within weather systems is in the public domain as per NASA's public mission, and is propelling research within the campaign and beyond.

What the skies tell us

One key finding, Davis said, is that we have a better understanding of how greenhouse gases—particularly methane—pool within and are transported by weather systems.

This comes into play heavily as nations grapple with solutions for climate change. They need to know the sources and the sinks—processes where greenhouse gases are emitted into or remove from the atmosphere.



David C. Bowman, NASA

Bianca Baier, then a postdoctoral researcher and now a research scientist at NOAA, and Ken Davis, ACT-America principal investigator, talk during a flight. Baier received her B.S. in mathematics, her M.S. in atmospheric chemistry, and her Ph.D. in atmospheric chemistry, all from Penn State.

"With this campaign, we've begun to improve our tools for auditing greenhouse gas sources and sinks as nations try to manage climate change. If we can't measure the sources and sinks well then we're flying blind. We don't know the impact we're having. These atmospheric measurements have a lot of promise for helping us identify and quantify these sources and sinks."

~Ken Davis

This plays out in another key finding of the mission: the true impact of the oil and natural gas industry on climate change. Using ethane as a tracer, researchers, for the first time in a multi-season, continental-scale atmospheric campaign, revealed the sources of the methane seeping into the skies. Methane, which is produced from oil and gas wells and also biologically in cows and other processes such as rice paddies, wetlands, coal mines, and landfills, is more than eighty times as potent over twenty years as the greenhouse gas carbon dioxide but has a life in the atmosphere of about ten years, far less than the hundreds of years for carbon dioxide. Ethane isn't present in livestock produced methane.

Davis' team found that emissions of methane from oil and natural

Davis took this photo over the midwest during a flight to validate remote sensing data from the Orbiting Carbon Observatory-2 (OCO-2) satellite. OCO-2 uses near infrared reflection to make its measurements of carbon dioxide. Snow is dark in the near infrared, though, meaning it's not reflective, so satellite validation flights like this one can help researchers see how well OCO-2 is working as it collects measurements while orbiting over snow-covered land.

gas wells were at least 60 percent greater than those estimated by the EPA's method for emissions accounting.

This discrepancy, said Zach Barkley, assistant research professor, points to problems with the EPA's inventory approach. The inventory is an accounting method based on data like well counts, gas production, and typical leak rates for the equipment used in the gas and oil production fields. However, Barkley said, the method is simply missing a lot of gas.

"There are systematic problems in the way the EPA calculates these emissions and natural gas has just always been a larger source than we expected," Barkley said. "The next task, obviously, is to figure out where these emissions are coming from and find the most efficient way to reduce them."

Efforts to use satellites such as the Orbiting Carbon Observatory are coming into the fold. The good news, said Davis, is that their team found the methods—which estimate the carbon dioxide levels using sunlight that's reflected from Earth—to be very accurate. There was no discernible difference between the spatial gradients in aircraft-based and satellite-based carbon dioxide measurements when the skies were clear.

That's great news, said Davis. However, warm and cold fronts within weather systems are known for two things: clouds and transport of greenhouse gases, and currently satellite instruments can't measure greenhouse gases through clouds. So, work remains.

Science of weather systems

Improving how fronts and storms are represented in models allows us to improve our models of atmospheric greenhouse gas transport, said Tobias Gerken, assistant professor at James Madison

David C. Bowman, NASA

The ACT-America team with the two specially designed planes, a B200 King Air (upper left) and C-130 Hercules (upper right), designed to investigate how weather impacts the flow of greenhouse gases across large portions of the United States.

University who worked on ACT-America while at Penn State, because it lets us connect the dots between regional and global measurements.

Currently, we grab greenhouse gas measurements from data points and rely on inversion models to paint the regional snapshots that collectively add up to the global carbon footprint.

"In order to understand how good these inversion models are, we need to understand how greenhouse gases flow through the atmosphere," Gerken said. "ACT-America was a really interesting project to work on because it reveals what's happening on a regional scale. It's the bridge between local and global data."

Investing in answers

"We are crucially dependent on understanding greenhouse gas processes going into the future," Gerken said. "So, we need the best possible tools available. That's an investment for NASA and the American taxpayer. Because of all the graduate students who worked on this project, it's also an investment in training the next generation of scientists at this critical time for climate change."

Davis said the research fills in some of the unknowns as we seek answers to auditing and managing climate change.

"With this campaign, we've begun to improve our tools for auditing greenhouse gas sources and sinks as nations try to manage climate change," Davis said. "If we can't measure the sources and sinks well then we're flying blind. We don't know the impact we're having. These atmospheric measurements have a lot of promise for helping us identify and quantify these sources and sinks." ⌘