HARVESTIN

The growing role of biofuels

By Leigh Cooper

Carsten Warneke, a CIRES atmospheric chemist with NOAA, spent a summer in the cornfields of northern Colorado, studying chemicals emitted from the crops and marveling at the vigorous plants. "It's really amazing how fast corn grows," Warneke says. "On some days, when the weather was good, it grew almost an inch per day."

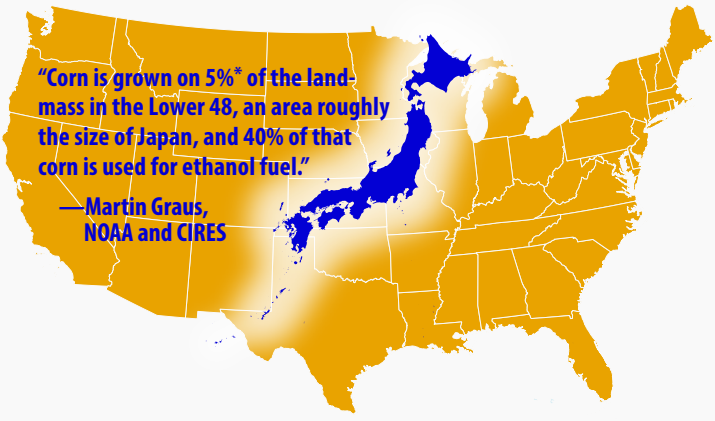
He and his colleagues had good reasons for plunking themselves down in the middle of Colorado State University's cornfields to watch corn grow. The demand for biofuel crops, such as corn, is soaring. Federal regulations passed in 2005 and 2007 require that biofuel must be mixed with gasoline, in increasing amounts, with the goal of fostering a renewable, domestically produced transportation fuel. In 2010, most gasoline at U.S. pumps contained 10 percent ethanol, made primarily from corn, compared to 1 to 2 percent in the early 2000s.

And atmospheric researchers are eager to know the effects this shift has had on air quality and climate. Plants naturally emit chemicals called volatile organic compounds (VOCs), which can contribute to the formation of the regulated pollutant ozone. VOCs can also influence regional and global climate by enabling the formation of aerosols, tiny airborne particles that alter the amount of radiation the atmosphere absorbs and reflects.

But what VOCs do biofuel crops, especially corn, emit and how might they affect regional air quality, the team wanted to know. From their investigations, they discovered that "corn's main VOC emission is methanol, which is not very reactive in the air," Warneke says. "This means the air quality implications of growing corn are expected to be relatively small."

Comparing crops

Along with corn ethanol, the federal regulations also require that some of the biofuel added to gasoline comes from non-starch feedstock, such as switchgrass, instead of corn. The rule's motivation: Non-starch feedstocks do not compete as a food source, and in some places, they can be grown using less energy and water. So industry and scientists are investigating woody plant and grass alternatives, such as switchgrass and poplars, to feed ethanol production. They're also looking at the environmental impacts of each.



"Corn is grown on 5%* of the landmass in the Lower 48, an area roughly the size of Japan, and 40% of that corn is used for ethanol fuel."

—Martin Graus, NOAA and CIRES

Until now, few studies have measured the volatile organic compound emissions of crops, even common ones like corn, which are potentially significant sources.

** U.S. Department of Agriculture figure*

G ENERGY

MARTIN GRAUS/CIRES

CIRES' Allyson Eller (in front) and Rui Li (background) set up a pole for corn height measurements during a 2011 study in Colorado.

In one study, CIRES scientist Martin Graus and his team measured the VOC emissions of 30 species of poplar trees, a potential source of cellulosic ethanol. Emissions increased when the plants were photosynthesizing and growing faster, and the genetic strain of the plants made a difference, too. Some VOC emissions from poplars were significantly higher than from corn and from switchgrass. At present, the use of poplars and other woody species for ethanol production is in its infancy.

Informing decisions

With half of all ethanol expected to come from non-starch feedstock in the near future, these studies may help guide decisions concerning which biofuel crops to grow. "Whenever you change an existing ecosystem, it's better to be informed beforehand about what's going to happen after you make a big change than having to dial back and fix it," Graus says.

The scientists' research to quantify VOC emissions from crops may also help improve the accuracy of climate and air quality forecasts. Current models don't differentiate emissions from different crop varieties—corn versus wheat, for example.

"If you want to study the atmospheric chemistry of a continent or a large region, you need to know which sources are putting chemicals into the big chemical reactor we call the atmosphere," Graus says.

Biofuels wafting in the air

Ethanol, now used commonly in U.S. gasoline mixtures, is turning up in urban air at more than six times the levels measured a decade ago, according to research led by CIRES and NOAA scientists.

Using research planes, Joost de Gouw, a NOAA-funded CIRES scientist, and his colleagues measured urban air quality during four research campaigns between 2002 and 2010. "The rise of ethanol in urban air is consistent with the rise in ethanol use," de Gouw says. "It should not have been unexpected perhaps, but it was certainly striking."

Ethanol itself is not considered very reactive, but it can be oxidized to create acetaldehyde, a hazardous pollutant and precursor for ozone formation. Surprisingly, though, de Gouw found that in Los Angeles, despite increases in atmospheric ethanol concentrations, acetaldehyde had decreased. "The reason is that acetaldehyde is formed from ethanol but also from a lot of other pollutants," de Gouw says. "And all of those pollutants had gone down as motor vehicle emissions became (or grew) cleaner over the years." (See "Skies of Blue," page 5.)

In the future, shifts in fuel composition and biofuel use could further affect the atmosphere's composition and chemistry. "As we develop new fuels, we need to know how the atmosphere is affected so we can make the best choices," de Gouw says.