Land use and irrigation yield a change in the weather in the Corn Belt

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The sweeping land use changes and irrigation of the U.S. Corn Belt, along with the influence of the area's shallow groundwater, have significantly altered precipitation patterns in that vital agricultural

region, new research shows.

The study, published in the *Proceedings of the National Academy of Sciences*, focuses on "precipitation recycling"—a process in which the moisture released to the atmosphere by plants, soils, lakes, and other features of the landscape returns to the same area in the form of rain.

By using advanced computer modeling techniques, scientists were able to determine that the region's agriculture, combined with shallow groundwater, increases the precipitation recycling ratio by almost 30%. This provides a significant boost to rainfall during the growing season.

The role of precipitation recycling varies from month to month and year to year, the research found. It peaks in the summer months with the maturing of the corn crop, and in dry years when little moisture arrives from other regions.

"This research shows how agricultural practices can modify regional climate, with implications for food and water security," said lead author Zhe Zhang, a scientist with the U.S. National Science Foundation National Center for Atmospheric Research (NSF NCAR). "In an agricultural region like the U.S. Corn Belt where rainfall is critical, it's important for both farmers and water resource managers to understand where the rain comes from."

Learning more about the extent of precipitation recycling can help improve future rainfall predictions for the Corn Belt and provide more information for planting strategies and water resource allocations.

Altered land surface

The U.S. Corn Belt spans a dozen states in the Midwest and Great Plains, ranging from Ohio in the east to Nebraska in the west. The land surface,

which had been a mix of tallgrass prairie and woodlands prior to European settlement, is now characterized by croplands with extensive irrigation.

Previous research has shown that the region has become increasingly humid, with more rainfall. But Zhang and his colleagues wanted to quantify the impact of precipitation recycling.

Taking advantage of advanced computer modeling techniques, the scientists turned to the NSF NCAR–based Weather Research and Forecasting (WRF) model, which can simulate the atmosphere at a very high resolution of four kilometers (about 2.5 miles). They also used another NSF NCAR–based computer model, known as Noah-MP, which allows specific analysis of the interactive system of groundwater, crop growth, and irrigation. They applied a physically realistic algorithm to trace the movement of water vapor in the simulations.

To tease out the roles of agriculture and the shallow groundwater that's a natural feature in the region, the scientists compared simulations that included crops, irrigation, and groundwater with other simulations that lacked one or more of those factors. They ran the models at the NSF NCAR–Wyoming Supercomputing Center.

The results showed the precipitation recycling ratio—or fraction of precipitation that fell as a result of local processes—reached 18% because of the combination of shallow groundwater that fed moisture to the surface, leafy corn plants that released moisture to the atmosphere, and evaporation from irrigation systems. Without such factors, the modeling showed the precipitation recycling ratio would be just 14%, or about 29% less.

The scientists focused their simulations on three years: 2010 (which was unusually wet), 2011 (average precipitation), and 2012 (a dry year).

They found that the fraction of recycled precipitation was highest in 2012, when less moisture arrived from other regions such as the Gulf of Mexico.

"We were able to truly distinguish how different processes contribute to changes in precipitation," Zhang said. "Since agriculture relies on rainfall, this understanding can inform agricultural management as well as lead to a better understanding of freshwater availability."

He and his collaborators are planning subsequent research to look into how the changing precipitation can affect agricultural productivity.

More information: Zhe Zhang et al, US Corn Belt enhances regional precipitation recycling, *Proceedings of the National Academy of Sciences* (2024). DOI: 10.1073/pnas.2402656121

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