Cities affect storms, but downwind areas can get the worst of it

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(PhysOrg.com) -- Urban areas modify thunderstorms that can eventually get stronger and more violent as they leave the cities and move to downwind areas, according to a Purdue University study.

Using 10 years of data from storms around the Indianapolis metropolitan area, Dev Niyogi, an associate professor of agronomy and earth and atmospheric sciences, observed how storms altered as they approached an urban area.

"About 60 percent of the daytime thunderstorms seem to change their characteristics," said Niyogi, lead author of the findings reported in the *Journal of Applied Meteorology and Climatology*. "Before the storms approach the urban area, we see them as a more organized line of storm cells. As the storms get past the urban area, there are smaller but more cells, signifying splitting. So, quite often, we see storms approach the city, split around it and come back together on the other side to create a more intense storm."

Niyogi, who also is Indiana's state climatologist, said most of the storms that followed the pattern occurred during the daytime and preceded or came with a cold front. He and his team analyzed the storms' changing characteristics on radar, as well as on a time lapse statistical analysis that measured the size and number of cells present as a storm passed over the Indianapolis urban area.

Niyogi's graduate students, Patrick Pyle and Lei Ming, used a weather model to run simulations of the conditions that preceded the storms. In some simulations, the Indianapolis urban area was removed, changing the weather patterns.

"Interestingly, the storms only appeared in the model simulations when the Indianapolis urban area was present," Niyogi said. "This shows that the urban area can help create an environment that can at times trigger storms."

Niyogi said a number of factors are at play - tall buildings alter wind patterns, and heat and pollution can affect the creation of storms.

"What the storm is really responding to is those changes in the environment," Niyogi said. "All three of those - the change in landscape from rural to urban, heat and particulates - in some way affect the environment around the city."

Niyogi also analyzed storms about 46 miles away from Indianapolis and did not see the same patterns that formed when storms passed through the urban area.

Niyogi believes understanding how land use could affect storms would lead to better weather and flood predictions. He said it might be possible to use data on land use and weather when planning construction to lessen the impacts storms might have on the surrounding areas.

"While we cannot control a large thunderstorm, our research does bring up the possibility that the impact of these thunderstorms can be affected by land-use planning," Niyogi said.

Niyogi is working to create interactive simulations that allow researchers to study how changes to the landscape might change weather patterns. NASA, the U.S. Department of Energy and the National Science

Foundation funded parts of this the research.

More information: Urban Modification of Thunderstorms: An Observational Storm Climatology and Model Case Study for the Indianapolis Urban Region, *Journal of Applied Meteorology and Climatology*.

ABSTRACT
A radar-based climatology of 91 unique summertime (May 2000–August 2009) thunderstorm cases was examined over the Indianapolis, Indiana, urban area. The study hypothesis is that urban regions alter the intensity and composition/structure of approaching thunderstorms because of land surface heterogeneity. Storm characteristics were studied over the Indianapolis region and four peripheral rural counties approximately 120 km away from the urban center. Using radar imagery, the time of event, changes in storm structure (splitting, initiation, intensification, and dissipation), synoptic setting, orientation, and motion were studied. It was found that more than 60% of storms changed structure over the Indianapolis area as compared with only 25% over the rural regions. Furthermore, daytime convection was most likely to be affected, with 71% of storms changing structure as compared with only 42% at night. Analysis of radar imagery indicated that storms split closer to the upwind urban region and merge again downwind. Thus, a larger portion of small storms (50–200 km2) and large storms (>1500 km2) were found downwind of the urban region, whereas midsized storms (200–1500 km) dominated the upwind region. A case study of a typical storm on 13 June 2005 was examined using available observations and the fifth-generation Pennsylvania State University–NCAR Mesoscale Model (MM5), version 3.7.2. Two simulations were performed with and without the urban land use/Indianapolis region in the fourth domain (1.33-km resolution). The storm of interest could not be simulated without the urban area. Results indicate that removing the Indianapolis urban region caused distinct differences in the regional convergence and convection as well as in

simulated base reflectivity, surface energy balance (through sensible heat flux, latent heat flux, and virtual potential temperature changes), and boundary layer structure. Study results indicate that the urban area has a strong climatological influence on regional thunderstorms.

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