Clearest Video of Lightning-Generated 'Sprites' High Above Thunderstorms Captured

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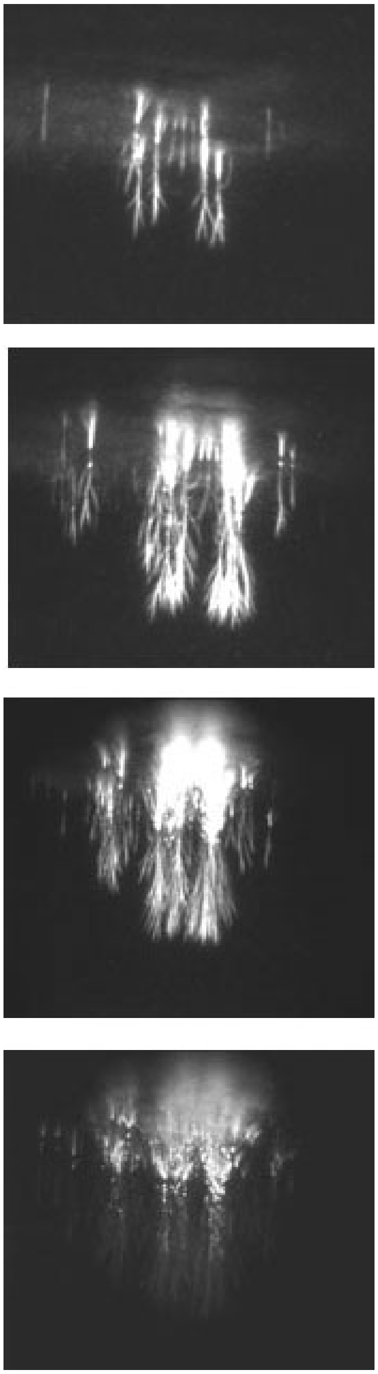
Researchers at Duke University's Pratt School of Engineering have captured the best images ever produced of "sprites" -- mysterious flashes of light resembling giant undulating jellyfish that can occur above strong thunderstorms -- using a high-speed camera that recorded thousands of video frames a second.



Images from video capturing sprites.

The researchers said their findings could lead to a better understanding of the physics and chemistry of this fleeting, still-unexplained lightning phenomenon. They recorded and analyzed video of sprites associated with powerful thunderstorms occurring over the Great Plains during the summer of 2005. Their findings are scheduled to appear online in *Geophysical Research Letters* on Feb. 22.

"By analyzing the high-speed images in sequence, we've been able to clearly define, for the first time, the processes by which sprites develop and what happens inside of them," said Steven Cummer, assistant professor of electrical and computer engineering at Duke's Pratt School. "This understanding of sprite structure is a necessary step to further elucidate sprite dynamics and their possible effects on the upper atmosphere."

Sprites are one of the most common of a number of so-called mesospheric transient luminous events (TLEs) driven by lightning, Cummer said. Other such lightning-related phenomena include blue jets, elves and terrestrial gamma ray flashes.

Since sprites were discovered in 1989, scientists have been attempting to measure and document them, Cummer said. The first high-speed images of sprites were reported by other researchers in 1999. Shortly thereafter, a second group captured the first images of sprites recorded at 1,000 frames per second.

"Each improvement has revealed important new information about the processes involved and their possible larger scale impact on the upper atmosphere," Cummer said in an interview. "However, many sprites develop too quickly to be fully resolved even at one millisecond time resolution."

Sprites typically last for 10 to 100 milliseconds -- shorter than the blink of a human eye, which takes an average of 300 to 400 milliseconds. Their transience makes sprites difficult to see with the naked eye, despite their common occurrence in association with certain types of active thunderstorms, the researchers said.

The vantage point required for a good view also complicates direct observation of sprites, said Nicolas Jaugey, a member of Cummer's team at the Pratt School. Sprites generally form between 20 and 50 miles above storms and can often be obscured by lower lying thunderclouds. Therefore, it's best to view them from a mountaintop or other high point about 100 to 300 miles away from a storm, he said.

The Pratt team -- along with collaborators Walter Lyons and Thomas Nelson of FMA Research Inc. in Fort Collins, Colo. – set up an intensified high-speed camera capable of recording more than 5,000 frames per second at the Yucca Ridge Field Station in Fort Collins from July through August 2005. From that site, the researchers could look out over the Great Plains to image storms occurring over Kansas and Nebraska.

Night after night, the group watched the weather forecast for conditions ripe for sprites, said Jaugey, who was in Fort Collins for the duration of the research campaign. When a promising storm was brewing, the researchers pointed the high- speed camera in the right direction and watched events unfold remotely on a television displaying video from a low-light camera.

"Sometimes we'd get lucky and there would be a sprite every 10 to 15 minutes," Jaugey said. "Other times, we would wait for four hours and only get two events."

Although much of the time was spent waiting, the researchers had to keep a very close watch in order to capture the sprites. The events happen so fast that they would often occur in just one normal speed video frame, Cummer said.

"They happen about as fast as you can possibly see anything on a normal television," he said.

"We had to watch for brief flashes and call them out when they happened," added Jaugey. This meant that the team had to be particularly adept at differentiating flashes indicative of a sprite from lightning itself.

When the proper type of flash was seen, one of the team members pressed a button to start the high-speed camera recording. The cameras record so much data so quickly that they can only be activated when a suspected sprite occurs, they explained.

"When we knew a storm was good, it wasn't a problem to wait," Jaugey said. "When a sprite is captured on film, it's extremely exciting. You see just a flash on the TV screen, but when you retrieve the recording from the high-speed camera and see its development, it's very beautiful."

Over the entire field season, the researchers captured 76 TLE sequences on seven different nights, 66 of which contained distinguishable sprite elements, they reported. As luck would have it, they produced the best images on the night of Aug. 13 -- their very last day in the field, the researchers said. It is those images that the team analyzed in detail in the latest report.

Based on the observations, sprites normally begin almost 50 miles high as downward-moving "streamers" that appear spontaneously or at the bottom of a halo -- diffuse flashes of light often associated with sprites. The streamers then branch out as they move down. At the same time, a brighter column of light expands both up and down from the starting point, followed by bright streamers that shoot higher into the sky.

The group's videos also revealed new details of "isolated dots," bright spots of light -- first described by other investigators -- that often glow for longer than any other portion of the sprite. The pictures show that some of these bright spots form when individual streamers collide, presumably as a result of electrostatic attraction between them, according to the researchers.

The greater energy intensity found at those spots makes them particularly important for understanding the impact of sprites on atmospheric chemistry, Cummer said.

“Electrons with enough energy to produce light can also produce interesting chemical species not normally generated,” Cummer said. “Such chemicals might be long-lived and could be transported to other locations through the atmosphere.” Because isolated dots persist for the longest, they may be sites where a significant portion of such chemical reactions occur.

The new insight into how these bright spots form could lead other researchers to produce better models of their physics and chemistry, he said. The Duke team will also conduct further analyses to relate their sprite image sequences to information they gathered on the lightning-produced magnetic and electric fields that spawned them.

“We should be able to make new connections between the lightning strength and speed required to produce these phenomena in the upper atmosphere,” Cummer said.

Other collaborators on the study included Jingbo Li, of Duke, and Elizabeth Gerken, of SRI International in Menlo Park, Calif.

High-speed video of a lightning-generated sprite is available in Quicktime format.

Source: Duke University