Space shuttle Columbia's last flight formed clouds over Antarctica

July 6 2005

A burst of mesospheric cloud activity over Antarctica in January 2003 was caused by the exhaust plume of the space shuttle Columbia during its final flight, reports a team of scientists who studied satellite and ground-based data from three different experiments. The data also call into question the role these clouds may play in monitoring global climate change.

"Our analysis shows that the Columbia's exhaust plume approached the South Pole three days after launch," said Michael H. Stevens, a scientist at the Naval Research Laboratory and lead author of a paper scheduled to be published in the July issue of the journal Geophysical Research Letters. "The lower temperatures and high concentrations of water vapor over Antarctica caused a significant increase in polar mesospheric cloud activity."

Polar mesospheric clouds are the highest on Earth, forming at an altitude of about 52 miles. They normally form when temperatures fall below minus 125 degrees Celsius.

"Because the brightness, occurrence and range of the clouds have been increasing, some scientists have suggested that these clouds are indicators of global climate change," said Xinzhao Chu, a research scientist at the University of Illinois at Urbana-Champaign and a co-author of the paper. "That role needs to be reconsidered, however, because of the potential influence of water vapor in shuttle plumes."

On Jan. 16, 2003, the Columbia lifted from Kennedy Space Center on its final flight before the loss of the crew and orbiter 16 days later. As with previous shuttle launches, the orbiter released about 400 tons of water -- the primary product of the liquid hydrogen and liquid oxygen fuel -- while flying nearly horizontally at an altitude of 68 miles. The resulting plume was about 2 miles in diameter and about 650 miles long.

"The plume was detected and tracked by the Global Ultraviolet Imager on NASA's Thermosphere, Ionosphere, Mesosphere, Energetics and Dynamics satellite," Stevens said. "The GUVI images reveal rapid movement of the shuttle plume toward the South Pole."

At the Rothera Research Station in Antarctica, Chu was measuring upper altitude iron densities and polar mesospheric clouds using a special lidar system designed by Illinois and operated in collaboration with the British Antarctic Survey. Three days after the launch, the lidar detected iron in the atmosphere at altitudes much higher than usual.

"In addition to a persistent layer of iron near an altitude of 56 miles, produced from ablating meteoroids entering Earth's atmosphere, three anomalous iron features were found at altitudes between 64 and 71 miles," Chu said.

Too high to be caused by meteoroids, these iron features originated in the shuttle plume, the researchers report, and had been produced by the normal ablation of main engine components during launch.

"Within the next two weeks we measured almost all of the polar mesospheric clouds we were to see that season," Chu said. "Only four hours of cloud observations were recorded before mid-January. From January 19-26, however, 18 hours of cloud observations were recorded." The increase in polar mesospheric clouds was also observed with the Solar Backscatter Ultraviolet instrument on the NOAA-16 satellite.

Additional evidence that the shuttle plume was responsible for the burst of cloud activity can be found in the mesopause temperature, inferred from the iron observations near an altitude of 56 miles, the researchers report. At Rothera, the mesopause temperature was minus 120 degrees Celsius, which is too warm for polar mesospheric clouds to form under typical water vapor concentrations. By dumping so much water vapor into the mesosphere, the shuttle raised the concentration enough to allow the clouds to form.

"Our data will force scientists to rethink the role of polar mesospheric clouds in monitoring global climate change," Stevens said. "Any interpretation of recent trends in cloud activity must consider the potential influence of the space shuttle program."

Source: University of Illinois at Urbana-Champaign