Miniature lab ice spikes may hold clues to warming impacts on glaciers

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Ice penitentes in Andes. Image courtesy Javier Corripio, Federal Institute of Technology, Zurich

Tiny lab versions of 12-foot tall snow spikes that form naturally on some high mountain glaciers may someday help scientists mitigate the effects of global warming in the Andes, according to a University of Colorado at Boulder professor.

CU-Boulder physics Assistant Professor Meredith Betterton said the spikes, known as penitentes, are shaped when concentrated rays of sunlight evaporate snow from low spots on glacier fields in a process known as sublimation. The lab studies confirm that the low spots, or

troughs, deepen as intense sunlight strikes them, sculpting penitentes by the hundreds of thousands on some glaciers, she said.

Some scientists have predicted that penitentes might help put the brakes on shrinking glaciers in a warming climate by blocking sunlight that might otherwise be absorbed by glacial surfaces, said Betterton. She gave a presentation on penitentes at the March Meeting of the American Physical Society in Denver March 5-9.

"The key piece of physics here is that the dips in the snow absorb more reflected light, which drops the snow height and helps to form the penitentes," she said. "One big question is how penitentes will fare in a warming world."

Betterton, along with colleagues Vance Bergeron and Charles Berger from Ecole Normale Superieure research laboratories in Paris, sprouted miniature penitentes in the lab to better understand the physics behind their formation. Penitentes -- named for their resemblance to a procession of white-hooded monks -- were first described by naturalist Charles Darwin during an expedition to South America he and his crew made in 1835 aboard his ship, the Beagle.

The research team put a block of snow in a horizontal freezer in Paris filled with water vapor and chilled with liquid nitrogen, covered it with a clear Plexiglas lid, and shined a spotlight on the snow to simulate sunlight, Betterton said. Tiny snow spikes up to two inches high formed within a few hours, apparently by the same process through which penitentes form naturally on alpine glaciers, she said.

The study confirmed previous theories that penitentes grow when sunlight in cold, dry air in the high mountains strikes snow patches and transforms them directly into water vapor, she said. Mathematical models developed by Betterton indicate microscopic penitentes begin

merging with each other, or "coarsening," early in the sublimation process, growing both taller and wider over time.

The research has applications for understanding and even mitigating global warming, since Andean penitentes shade large areas of glacial surfaces, possibly cooling them and slowing the rate of ice loss, she said. Some scientists believe warming temperatures could trigger the eventual destruction of vast fields of penitentes and hasten glacier melting, "which would be disastrous for Argentinean and Chilean regions that depend on runoff for water supplies," said Betterton.

Betterton and her colleagues took the research a step further, sprinkling the sprouting lab penitentes with a fine layer of carbon soot to simulate pollutants known to be accumulating on some glaciers around the globe. Such carbon-based pollutants have been found to increase melting rates on glaciers by causing the ice to absorb more sunlight and heat up, she said.

The team found that small amounts of soot sprinkled on the snow in the lab appeared to accelerate penitente formation. "One worry that scientists have is that without penitentes, some of these Andean glaciers will melt more quickly," she said. "It may well be that adding a small layer of dirt to the surface of these glaciers could help to preserve them."

The penitente research effort also has implications for the microelectronic industry, she said. Precisely shaped micro-penitentes formed by laser beams could lead to the development of solar energy cells that trap light more efficiently.

Source: University of Colorado at Boulder