Researchers measure trends of soot in a glacier, identify emission sources in a climate model

May 8 2015

The Zuoqiupu glacier is in the southeastern Kangri Karpo Mountains, on the margin of the Tibetan Plateau. Researchers are working to understand the warming influences on regional glaciers by tracking the historical record of soot particles in ice and snow. Studies to identify current particles source regions using novel modeling approaches help improve projections of future climate impacts. Credit: B. Xu

Soot from burning biomass and fossil fuels leaves a historical record frozen in snow and ice. Researchers at Pacific Northwest National Laboratory and collaborators designed a unique tracer tagging technique in a climate model to identify the particles' sources and the cause of their historical trends. Their results show that soot recorded in the southeastern Tibetan glacier, which has been increasing in recent decades, primarily originated in South Asia during non-monsoon months. This is consistent with a growing contribution from coal and biomass burning in South Asia. The results offer insights on the glacier-melting capacity of these particles and their impact on fresh water availability.

"With the new modeling technique, we can differentiate how much of the soot deposited to the Tibetan glacier is contributed by the regional monsoon versus emissions," said Dr. Hailong Wang, atmospheric scientist at PNNL who led the study's modeling work. "This will help us better understand ice core soot records, their seasonal dependency, and how closely they are associated with how soot is transported in the air and removed by rain or snow."

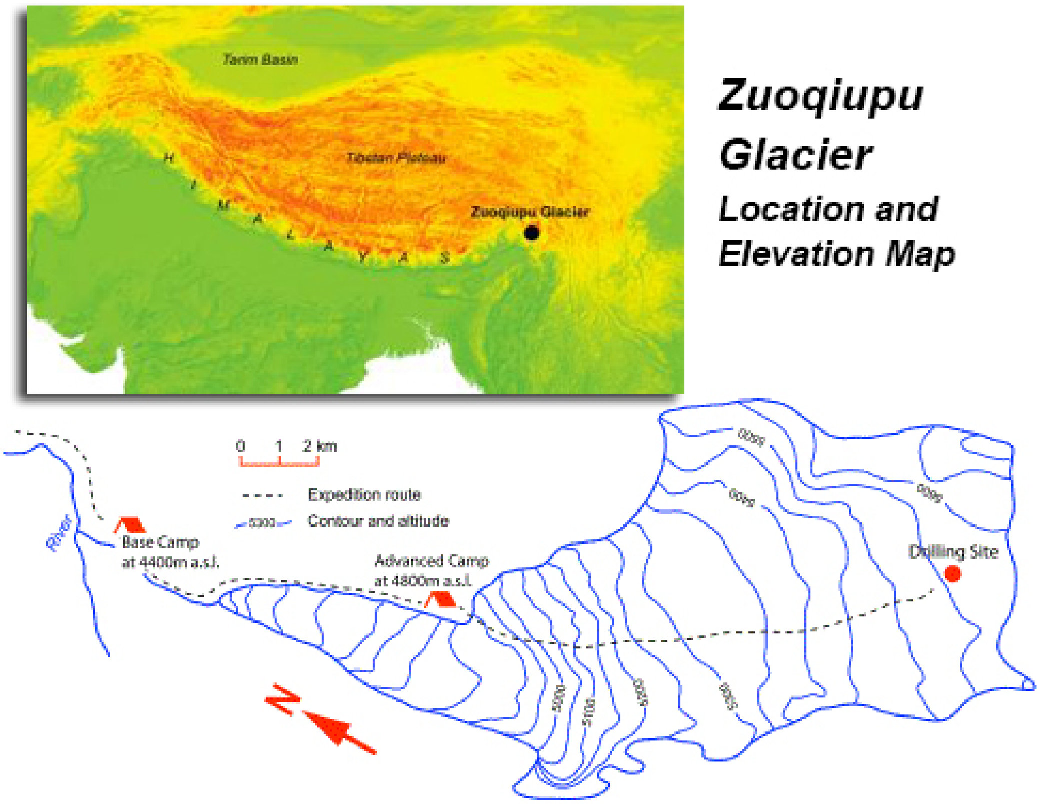
Black carbon (a.k.a. soot) and organic carbon particles flee from forest fires, diesel engines, and other fuel burning, becoming atmospheric hitchhikers. Riding the aerial circulation, they drop down in remote snow and ice regions to do their dirty work. These particles of black and organic carbon act like a heating blanket on the snow and ice by absorbing solar energy. This sets in motion increased melting through a feedback loop—more warming, more melting, more warming, more melting. The particles that researchers find in the snow and glaciers—mostly originating from far-away places—are the primary reason for this loop of warming and melting.

Researchers measured soot and organic carbon in ice core samples taken from the Zuoqiupu glacier in 2007. They used a climate model to understand the emissions, transport, and deposition of soot in the atmosphere. Credit: B. Xu

For humans, animals, and plants that rely on a long-lasting source of fresh water from seasonal glacier melting, the melting acceleration is troubling. By identifying the sources and quantities of these dark particles, planners and resource managers can better mitigate the long-term repercussions.

"With the new information from this study, we can reconcile the long-term trend of aerosols in the glacier with emissions from the primary soot-emitting regions," said Dr. Mo Wang, now a researcher at the Institute of Tibetan Plateau Research, Chinese Academy of Sciences, and the lead author of the study.

A lack of long-term data and observations of atmospheric carbonaceous aerosol emissions before the satellite-era has made it difficult to assess their impact on the historical regional climate. Ice-core measurements provide an ideal way to reconstruct the missing aerosol data.



Color map of the location of the Zuoqiupu glacier in the Tibetan Plateau. Elevation map and field study information shows path to the collection site and location in the glacier.

PNNL and collaborators from Chinese Academy of Sciences analyzed samples of a 50-year ice core taken from a southeastern Tibetan glacier. They assessed the soot and organic carbon (OC) concentrations that had distinct seasonal dependence and long-term increasing trends. Using a global aerosol-climate model called the Community Atmosphere Model version 5 (CAM5), with an explicit source tagging technique, they quantified the regional contributions to soot deposition on the Tibetan glacier. The study identified source regions, which differ in summer monsoon and non-monsoon months. They also used an offline radiative transfer model to quantify the impact of measured soot and OC on the energy budget in snow/ice and how these estimates vary with time.

Based on the temporal trends of soot, OC, and the OC/soot ratio in the ice core, the team identified changes over time in fuel types in the primary source region, which they found to be consistent with limited energy consumption data.

As part of the project, the new modeling tool is also being used to explore sources and the impact of carbon-containing particles in snow and ice over other locations of the Himalayas and Tibetan Plateau, as well as the Western North America. They will increase focus on the areas where the amount, source, and impact of these heat-trapping particles may be substantially different.

More information: "Carbonaceous Aerosols Recorded in a Southeastern Tibetan Glacier: Analysis of Temporal Variations and Model Estimates of Sources and Radiative Forcing." *Atmospheric Chemistry and Physics* 15:1191-1204. DOI: 10.5194/acp-15-1191-2015

Provided by Pacific Northwest National Laboratory