Discovering Chile’s hidden water treasures -- rock glaciers

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The world’s fresh water is stored and transported by a range of natural reservoirs and formations – streams, rivers, lakes, bogs, aquifers, glaciers , icebergs, clouds and highland mists, and of course, plants and animals. Another important yet poorly understood source of fresh water is rock glaciers. Geographers and hydrologists distinguish these frozen, debris-covered formations from ice-only glaciers.

A joint research project of the University of Waterloo in Canada and the Universidad Mayor in Chile has been investigating ways to accurately identify rock glaciers. The research collaboration, feeding into a broader effort in Chile and elsewhere, draws on Canadian expertise in physical geography and computer modelling and Chilean expertise in remote sensing.

Accurate identification of rock glaciers will provide better technical information to Chilean government scientists responsible for natural resource management and environmental assessments in the dry Andes, as well as to environmental NGOs. This step is particularly important in view of a 2008 Chilean law that requires environmental assessments of development projects in mountain areas – projects such as mining, disposal of mining tailings and road construction. Some such activities have caused friction in the past between mining firms and environmentalists.

But the potential long-term spillover benefits to other countries with rock glaciers, such as Argentina, and other regions, such as Central Asia, are significant too, says University of Waterloo geographer Alex Brenning. Argentina has a larger total area of rock glaciers, and it too has new glacier-related legislation; enforcing the new law will require accurate data on the extent of rock glaciers and their ice content.

Dr. Brenning describes the elusive aspect of rock glaciers: “You see absolutely nothing of all the ice that is on the ground. This means the research methods for investigating rock glaciers are very different from what’s used in glaciological research... so rock glaciers are not usually included in glacier inventories. Even now there’s very little knowledge about their distribution in many mountain areas of the world, except maybe the Alps and the Rocky Mountains."

What masks the ice of a rock glacier is the so-called “active layer” of rock, usually three- to-five metres thick. Visually, the formation resembles regular non-glacial terrain or permafrost. Since rock glaciers are a major source of water in the dry Andes, especially through seasonal melting, they need to be protected like other water resources. But to do so, their number, sizes and locations need to be spelled out.

This is where the work of Marco Peña comes in. Mr. Peña is a specialist in applied remote sensing with the Centre for Studies in Natural Resources (OTERRA) at the Universidad Mayor in Santiago. He's investigating techniques that can distinguish between rock glaciers and other land formations. Two promising approaches, he notes, are thermal inertia analysis and hyperspectral analysis, drawing on certain kinds of satellite images.

The thermal inertia method uses images of a mountain area taken at those times of the day when maximum and minimum temperatures are reached. "Thermal inertia depicts the response of a material to temperature changes," explains Mr. Peña. "By calculating thermal inertia we are able to find differences between rock glaciers and their surrounding areas."

Even though rock glacier materials may look like the surrounding material, the temperature of both landforms may be different because the rock glacier contains ice as well as rock, he says. Thus they have distinctive thermal and radiative properties that can be used to identify them.

Hyperspectral analysis relies on images taken by Hyperion, an instrument aboard NASA's EO-1satellite that has been collecting data about the earth since 1999. Mr. Peña hypothesizes that rock glaciers are spectrally different from surrounding materials. Again, the key is to find tell-tale signs of rock glaciers, in this case various combinations of elements in the surface of the target area that has been imaged. Hyperspectral analysis reveals more about a surface than other remote sensing techniques, due to the detailed spectral information available in each pixel of an image.

“We want to demonstrate to the remote sensing community that there is a close relationship between remote sensing and rock glaciers if proper, remotely sensed products are combined with field data,” says Mr. Peña. To this end, researchers staged a one-day seminar on the topic at Universidad Mayor a year ago, bringing together 27 students, university researchers, mining industry representatives, consultants, and staff from Chile’s national water authority.

Dr. Brenning stresses that global warming could have a significant impact on rock glaciers in many regions and thus on the world supply of fresh water in the form of ice. Hence, the importance of building rock glacier inventories now – not only to support environmental impact assessment for specific projects, but also for the long-term knowledge base needed to help protect vital water resources.

Glacier science was in the news recently, as Dr. Brenning was interviewed by Chilean and international media on the importance of rock glaciers. Because of his expertise, he was also asked to join a scientific group advising Chile’s national environmental protection agency on implementing its National Glacier Policy. He plans to spend part of 2011 working in Chile.

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