



# *communiqué*

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## **Melting the Ice – receding glaciers in the American Cordillera**

**Investigators from IAI projects share key messages on their research on glaciers in the American Cordillera. Most glaciers are shrinking, some may survive some will disappear, particularly in tropical and subtropical regions, but communities depending on rivers fed by glaciers and snow must already learn to adapt to changes in seasonal water flows .**

Himalayan glaciers will disappear by 2035. This conclusion in the 2007 IPCC report on “Impacts, Adaptation and Vulnerability” is an obvious mistake, but it was overlooked by the IPCC’s lead authors, and its discovery has re-heated the discussion on global warming as presented by the IPCC. Maybe understandably so, as it followed the controversy about e-mails hacked from East Anglia University in November 2009, which raised questions on how reliable data on global temperature change are and how transparent the process is by which they were calculated.

The IAI supports extensive research on the hydrology and on glaciers of the American Cordillera - the backbone of the continent from the Alaskan Rockies to the Southern Andes. We have therefore asked the scientists of these networks to offer their perspective on glacial melt on the American continent: Brian Luckman who leads one of the networks wrote back that "the 2035 date is clearly ridiculous given the number and volume of glaciers in the Himalayas - though it might be a reasonable assessment for the demise of the glacier cover in Glacier National Park in the USA." And this is the problem: in the politically charged and economically momentous debate on climate change predictions, few pause to reflect on the data, assess what changes are already happening and consider what can be done to adapt.

An assessment of changes in global glacier cover has been published by UNEP (<http://www.grid.unep.ch/glaciers> and <http://www.geo.unizh.ch/wgms>). Within the Americas, graphic documentation that the glaciers in the US Rocky Mountains and Glacier

National Park are disappearing rapidly is provided in the Repeat Photography Project of the US Geological Survey (<http://nrmsc.usgs.gov/repeatphoto/>). In Western Canada, a satellite and aerial photography inventory by the University of Northern British Columbia indicates that, between 1985 and 2005, ice cover decreased by approximately 11% and 25% in British Columbia and Alberta, respectively. Moreover, rates of decrease for the 2000-2005 period are approximately double those for 1985-2000, indicating an accelerating retreat.

### **A View from the South**

A "View from the South" was recently provided at a conference on ice and climate change in Valdivia, Chile. Glacier inventories have been completed or are near completion in many South American countries. In Bolivia, the Chacaltaya glacier which was being monitored by IAI researcher Edson Ramirez disappeared in 2009 and glaciers in the Tuni-Condoriri Basins that are important water sources have lost 40-50% of their area since 1955. It is likely that other small glaciers in tropical and subtropical regions of the Andes and in Mexico may also disappear in the next 20-40 years.

The IAI's glacier-related studies in Chile are on relatively small glaciers near San Lorenzo and in the Magallanes Region where new inventories based on new aerial photography are being prepared. In Argentina, the Institute of Snow and Ice studies, IANIGLA, part of the IAI's Cordilleran network, has developed inventories for areas in Southern Patagonia (49°S), the wet (40°S) and desert Andes (29°S) further north. In the wet Andes study, the ice cover decreased from ca. 100.5 km<sup>2</sup> to 90.5 km<sup>2</sup> (12%) with individual glaciers losing between 5.8 and 22% of their area. The southern Patagonian Icefield lost 500 km<sup>2</sup>, nearly 4% of its area, with the largest losses from Glaciar Jorge Montt (Chile) and Glaciar Upsala (Argentina), which receded ca. 10 and 6 km, respectively. Almost all outlet glaciers from the icefield are receding, but there are a few spectacular exceptions; Glaciar Pio XI gained 7.8 km<sup>2</sup> between 1986 and 2009. This points to the complexity of the climate processes involved.

Glaciers in the tropical Andes show the greatest losses. Bernard Francou from the French Institute for Research and Development (IRD) and his collaborators documented glacier area losses of 30-50% in the last three decades. Summarizing the Valdivia conference, Brian Luckman wrote that "glacier loss in the tropical Andes has accelerated considerably recently, especially after 1976." The years 1976/77 saw a change in the atmospheric circulation over the North Pacific Ocean, the Pacific Decadal Oscillation (PDO). An opposite shift of the PDO had previously occurred in 1945. These changes in the atmospheric circulation over the Pacific introduced two significant steps in rainfall, temperature and streamflow patterns over the past 65 years. On shorter time frames, El Niño events affect interannual mass balances of glaciers, bringing lower snowfalls to some regions and higher snowfalls to others in a well defined regional pattern.

IAI-sponsored work continues on glacier studies in Argentina (<http://www.glaciares.org.ar>), in particular on climate variability and change over the last 2000 years in southern South

America. This project examines glacier fluctuations but also seeks to reconstruct regional precipitation and temperature histories from which the main components of the regional atmospheric patterns (the Antarctic Oscillation, El Niño and also the PDO) can be reconstructed. These are important controls of the mass balance of glaciers - in different areas of the Andes glacier fluctuations are more strongly controlled by precipitation than by temperature changes. Understanding these linkages is important in examining the causes of recent glacier changes. These studies are also critical in understanding the variability and major controls of rain and snowfall that are inputs to both glaciers and other hydrological systems - and hence changing water supplies.

### **The larger picture**

Glaciers are obvious visible signs of climate changes. The Andes act as “Water Towers”, storage of water for the adjacent regions. When this storage is diminished as glaciers disappear, the rivers below will not necessarily dry up, but glacier and snow melt from the Andes are critical components of summer stream flow in many areas. IAI studies have shown the links between snowpack in the southern Andes and the flow regime of major rivers in Chile and Argentina. They identified the relationships between streamflow, snowfall and changes in the PDO in 1945 and 1977 that mirror equivalent changes in Canada and the USA.

Changing temperatures have major effects on snowfall. As cool seasons become warmer and snow turns to rain, the amount and duration of snowpacks decreases and the permanent snowline moves up-slope. These changes have significant effects on the seasonality of streamflows, increasing winter discharges whilst decreasing the availability of water during the summer when flows are primarily fed by snow and ice melt in the headwater regions. In many areas, such changes in snow cover are much more important hydrologically than the contribution from melting glaciers and therefore more important to document. Streamflows in central Chile and in Argentina already show changes in the seasonality with more flow earlier in the season.

Several major Andean cities rely heavily on glacier and snowmelt for their water supply. IAI studies in and around La Paz show demand increasingly outstripping the supply - a process that will be exacerbated by ongoing temperature changes. In many High Andean tropical and subtropical valleys spring and summer snow and glacier melt are critical for crops, livestock and human consumption. The Valdivia meeting showed significant awareness of glacier changes and concerns about their impact on livestock, the economic activities of many indigenous communities, and tourism.

Glacier changes are also a source of hazards in mountain areas. The major hazards are associated with outburst floods from lakes on, within or impounded against receding glaciers or against moraines. Major floods may also occur from hanging glaciers falling into lakes and displacing large quantities of water downstream. For example, five major floods from glaciers have occurred on Rio Colonia in Chile in the last 18 months and

possibly larger events could severely affect plans for hydroelectric developments downstream. Similarly, a large flood that occurred on Rio Manso at Tronador in Argentina on May 21, 2009, drained the lake in front of Ventisquero Negro and is the target of current investigations in the IAI's Collaborative Research Network 2047.

Development and human activities in the Andes strongly depend on the availability of water. Irrigation, hydropower, mining and the provision of water to households are multiple competing uses that can become sources of conflict if the amount and seasonality of streamflows change. In Mediterranean and semiarid regions, glaciers represent a very significant source of water. After snow has totally melted, glaciers become the most important source for surface water. In some cases, they represent the only source for the entire summer season. In rivers with nival regime, present streamflows match the seasonality of water demands, which are strongly determined by irrigated agriculture, with peak demands in midsummer.

As glaciers retreat and reduce their contribution to the water supply, irrigated agriculture faces important restrictions and yields are reduced in parallel with reduced water availability. Strategies for investment in infrastructure should focus on securing water resources, increasing water use efficiencies at all levels, and building dams and reservoirs sufficient to deal with both the limitations imposed by present, "known" climate variability and by future climate change and glacier retreat. From the Policy standpoint, we must also consider that the inevitable future increase of water demand will lead to conflicts among users/sectors. Therefore addressing global change requires the evaluation of efficient water allocation policies among different users, balancing economic and social considerations.

The glacier research in the American Cordillera provides several key messages. The status and significance of glacier losses varies considerably throughout the Americas. Most glaciers are undergoing rapid and accelerating melt, and many small, particularly tropical glaciers will disappear in the next few decades. Others will survive in a reduced state. Exceptions are very few glaciers in the far South which are actually growing. Glaciers are only part of the larger hydrological system, and in many cases changes in snowfall, which are also temperature dependent, may be more significant to future water supplies. The implications of these changes vary widely, depending primarily on how significant glacier melt and runoff are to the hydrological systems of each region. However, one thing is clear: both the loss of water storage and yield from glaciers and the related diminution in regional snow covers due to increasing temperatures has affected, and will continue to influence hydrological regimes significantly. Many social and economic activities depend on these water resources. Improving the knowledge on mountain snow and glacier cover remains a priority for developing sustainable water resource management and policies in these regions.