# MRI Newsletter 3: Understanding Climate Change in Mountains

Authors: Büchler, Bettina, Bradley, Ray, Messerli, Bruno, and Reasoner, Mel

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# MRI Newsletter 3: Understanding Climate Change in Mountains

*First results from field measurements leave no doubt; the extreme warm and dry weather conditions in the summer of 2003 had a profound impact on Alpine glaciers. According to data from global glacier monitoring programs, the thickness of European Alpine glaciers decreased roughly 5 times more than the average loss per year recorded during the already exceptionally warm period 1980–2000. This makes the loss of one single year about an order of magnitude higher than the reconstructed average loss per year during the 20th century (Prof. Wilfried Haeberli, personal communication 2004). These results demonstrate in an impressive but disturbing way how the impacts of climate variability or climate change are increasingly becoming perceptible. Such changes can only be documented and analyzed if high-elevation measurement sites are available.*

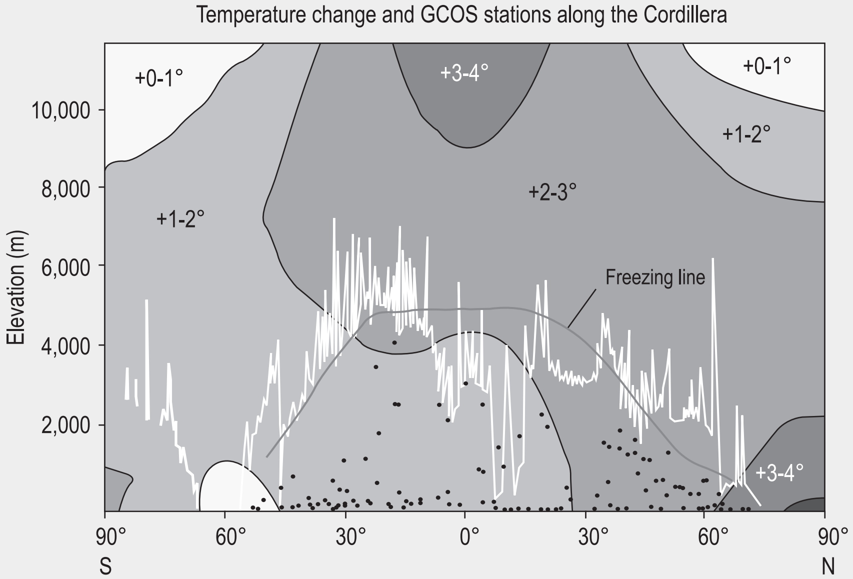

**FIGURE 1** Topographic transect through the western Cordillera of the Americas (white solid line) superimposed on GCM-based estimates of zonally averaged mean annual temperature changes expected with double $CO_2$ levels (IPCC 2001). Note that the greatest expected changes are at high latitudes near the surface, and in mid to low latitudes at higher elevations. Black dots: The current GCOS (Global Climate Change Observing System) surface stations plotted by elevation and latitude along the Cordillera. Note the large observational "data gap" in the mountain zone, especially from ~40°N to 30°S.

## Data gaps at high elevations

In its 3rd assessment, the Intergovernmental Panel on Climate Change (IPCC 2001) produced a series of future climate scenarios based on a number of General Circulation Models (GCM). A common feature of these models is that the anticipated warming of the next decades is expected to be more pronounced in northern middle and high latitudes. A less well-known feature of these IPCC scenarios is that the pattern of warming in the atmosphere is also expected to be more pronounced at progressively higher elevations in the troposphere, along a latitudinal gradient from the northern mid-latitudes to approximately 30°S, with a maximum above the tropics and subtropics (Figure 1). As the figure shows, many mountain regions are situated in these high-altitude zones of anticipated enhanced warming.

A number of disparate lines of evidence have indicated that the Arctic is already warming at a higher rate than other parts of the globe (Serreze et al 2000; Comiso 2002). In the western Arctic, the rapidly thinning ice pack and increasing thaw penetration into permafrost are two prominent examples of climate change impacts, where warming is occurring at a rate 3 to 5 times faster than in the rest of the world. Also, the rapidly receding glaciers in tropical mountains such as Kilimanjaro (Tanzania, 3°S), Quelccaya (Peru, 14°S), and the Dasuopu glacier (Tibet, 28°N) (Dyurgerov 2002; Thompson et al 2003) suggest that enhanced warming may be occurring at high-elevation sites near the equator, which would be consistent with IPCC model predictions.

However, very few high-elevation meteorological stations are situated at altitudes that would be appropriate for addressing this issue. For example, a transect along the crest of the North and South American Cordillera (Figure 1) shows a large observational 'data gap' in mountainous regions between approximately 40°N and 30°S. Although some climatic information for this region can be obtained from radiosonde measurements (though only 2 soundings per day are made), significant discrepancies between radiosonde and mountain surface data have been observed. Seidel and Free (2003) documented greater warming (and greater increases in freezing-level height) at tropical mountain locations than was recorded by radiosondes in the free air at similar altitudes. In other words, the detailed information necessary to assess climatic impacts in mountain environments requires direct measurements at high-elevation sites. As high and accelerating rates of change are associated with human impacts, data from high-elevation sites are also important in the process of teasing apart the climatic and direct anthropogenic drivers.

## Mountains susceptible to global change

An array of anthropogenic changes, involving land use and land cover changes, deposition of acidic and other pollutants, increasing atmospheric $CO_2$ concentration, and climatic changes threaten the functioning of fragile mountain systems. The collective effect of rapid environmental change and marked socioeconomic changes in mountain regions may significantly alter the ability of mountain regions to provide critical goods and services to both mountain inhabitants and lowland communities. Of particular significance are changing water regimes in the most critical climatic zones. As the number and magnitude of goods and services furnished by mountain regions are disproportionately large, it is crucial to understand how their availability and flow may be impacted by the anticipated environmental changes of the 21st century. Consequently, a sound understanding of the impacts of environmental and climate change in the world's mountain regions is imperative. However, this understanding will remain elusive unless the rather sparse current network of high-elevation monitoring sites is supplemented by additional long-term monitoring sites in the world's mountain regions.

## GLOCHAMORE: International Monitoring Workshop

The European Union's "Global Change and Mountain Regions" (GLOCHAMORE) action, in conjunction with MRI and UNESCO-MAB, takes a first step towards such a comprehensive monitoring network addressing global change in mountain regions. The thematic workshop "Global Environmental and Social Monitoring" taking place in May 2004 in Vienna, is the first in a series of 4 workshops addressing various research issues, followed by an Open Science Conference in 2005. The anticipated results of GLOCHAMORE will facilitate the implementation of interdisciplinary global change research strategies in a growing selection of UNESCO-MAB Biosphere Reserves around the globe.

Building on the results of the "kick-off" workshop in Entlebuch, Switzerland in 2003, the aim of the Vienna workshop is to develop an integrative working plan for environmental and social monitoring in high mountain regions. In the field of environmental monitoring, close collaboration with existing monitoring programs such as GLORIA (Global Observation Research Initiative in Alpine Environments) and GMBA (Global Mountain Biodiversity Assessment) is planned. It is anticipated that the monitoring strategies developed within GLOCHAMORE will finally begin to address the data gap due to a shortage of high-elevation climate monitoring sites around the world.

## Relevant references on the Internet

www.mri.sanwnet.ch (MRI homepage)

www.mri.sanwnet.ch/pages/GLOCHAMORE/G_Index.html (GLOCHAMORE homepage)

www.gloria.ac.at/res/gloria_home/ (Vienna Workshop)

www.unesco.org/mab/mountains/home.htm (UNESCO-MAB Mountain homepage)

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***Bettina Büchler, Ray Bradley,***
***Bruno Messerli, and Mel Reasoner***
Mountain Research Initiative (MRI), Coordination Office, Bärenplatz 2, 3011 Berne, Switzerland.
bettina.buechler@sanw.unibe.ch