GLACIOLOGICAL STUDIES IN THE CENTRAL ANDES USING AIRSAR/TOPSAR

Richard R. Forster, Andrew G. Klein, Troy A. Blodgett
and Bryan L. Isacks
Cornell University
Department of Geological Sciences
Snee Hall
Ithaca, New York 14853-1504

1. INTRODUCTION

The interaction of climate and topography in mountainous regions is dramatically expressed in the spatial distribution of glaciers and snowcover. Monitoring existing alpine glaciers and snow extent provides insight into the present mountain climate system and how it is changing, while mapping the positions of former glaciers as recorded in landforms such as cirques and moraines provide a record of the large past climate change associated with the last glacial maximum. The Andes are an ideal mountain range in which to study the response of snow and ice to past and present climate change. Their expansive latitudinal extent offers the opportunity to study glaciers in diverse climatic settings from the tropical glaciers of Peru and Bolivia to the ice caps and tide-water glaciers of sub-polar Patagonia.

SAR has advantages over traditional passive remote sensing instruments for monitoring present snow and ice and differentiating moraine relative ages. The cloud penetrating ability of SAR is indispensable for perennially cloud covered mountains. Snow and ice facies can be distinguished from SAR's response to surface roughness, liquid water content and grain size distribution. The combination of SAR with a coregestered high-resolution DEM (TOPSAR) provides a promising tool for measuring glacier change in three dimensions, thus allowing ice volume change to be measured directly. The change in moraine surface roughness over time enables SAR to differentiate older from younger moraines.

Polarimetric SAR data have been used to distinguish snow and ice facies (Shi et al., 1991) and relatively date moraines (Forster et al., 1992). However, both algorithms are still experimental and require ground truth verification. We plan to extend the SAR classification of snow and ice facies and moraine age beyond the ground truth sites to throughout the Cordillera Real to provide a regional view of past and present snow and ice. The high resolution DEM will enhance the SAR moraine dating technique by discriminating relative ages based on moraine slope degradation (Bursik, 1991).

2. 1993 FIELD CAMPAIGN

The 1993 South American AIRSAR campaign acquired data at four sites in the Peruvian and Bolivian Andes. TOPSAR data was acquired at all

sites. Three of the four sites, the Quelccaya Ice Cap, the Cordillera Blanca, both in Peru, and the Cordillera Real, Bolivia were targeted for their numerous modern glaciers and Pleistocene glacial landforms. The fourth, Potosi, Bolivia was chosen for its well preserved multiple moraines and alluvial outwash plains. The Cordillera Real was chosen as the ground truth site because of the easy access to its glaciers.

Ground truth data were acquired on two glaciers in the Cordillera Real during the AIRSAR flight. The two glaciers reside on adjacent mountains of the Cordillera north-east of La Paz. We recorded the following data from the Chacaltaya glacier: surface roughness profiles, snow depth transacts, and snow pit profiles of density, temperature,grain size distribution, and wetness. Measurements were taken on two days previous to the flight, the day of the flight and the day after the flight. Metrological data were recorded on the flight day and the following day. French collaborators from ORSTOM took a set of similar measurements on their research glacier, the Zongo glacier, during the AIRSAR flight. Four corner reflectors (manufactured in Bolivia) were deployed and their positions determined with GPS on and around the Chacaltaya glacier for co-regestation. The entire Cordillera was imaged with six swaths, five parallel to the mountain range and one oblique, optimizing the viewing geometry of the two neighboring ground truth glaciers.

During the two weeks after the SAR flight we collected samples from original surfaces of moraine boulders at several locations in the Cordillera Real and at the Potosi site for ^{36}Cl cosmogenic ray dating. This will provide numerical dates for the SAR derived moraine chronology.

3. ANTICIPATED RESULTS

The measured surface roughness and dielectric properties (snow wetness, grain size distribution and density) of the snow and ice will be used to interpret the polarization signatures obtained from different snow facies present on the glaciers. We will also map the snow facies boundaries on the test glaciers and extrapolate these results to glaciers throughout the Cordillera. We anticipate this research will provide the ground work for establishing a three dimensional base line for future monitoring of annual snowline and glacier positions over a regional setting. This DEM will be used for comparison with our present digitized topography and SPOT derived DEMs. The high resolution DEM derived from TOPSAR combined with a regional moraine chronology will allow detailed glacier reconstruction and ice volume calculations for known times during the Pleistocene. The AIRSAR coverage of the Cordillera Real will overlap with a SIR-C/X-SAR site providing an instrument and temporal comparison. Data from the Patagonian SIR-C/X-SAR supersite along with a similar ground campaign will allow a direct comparison of polarimetric SAR response to high elevation tropical glaciers and mid-latitude low elevation glaciers.

4. REFERENCES

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