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Glacier inventories and recent changes on active ice-capped volcanoes of the Chilean Southern Andes

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Glaciers located on top of active ice-capped volcanoes have exhibited variable and contrasting behaviors during recent decades. Regional climate variability, i.e. tropospheric warming and reduced precipitation, are the main driving factor of recent glacier fluctuations, however, there is an increased awareness related to the role of volcanic activity in the explanation of some of the ongoing glacier responses. One interesting example of glacier-volcano interactions occurs at Volcán Michinmahuida (42°S) where the first glacier inventory has been undertaken by analyzing ASTER satellite images provided by the GLIMS project), yielding a total area of 81.4 km2 of ice distributed among 9 glacier basins in year 2007. This is a strato volcano showing moderate eruptive activity in historical times but being geologically connected to ice-free Volcán Chaitén. In May of 2008, and presumably after several centuries of inactivity, this ice-free caldera initiated an eruptive cycle which remains until present day. The predominant southwesterly winds drifted the volcanic ashes which were further deposited over Michinmahuida, just 17 kilometers to the East. Volcán Michinmahuida glaciers lost 13% of its area in the last two decades, following the general glacier retreat trend in the region. Superimposed on this long term trend, in November 2007 the three main tongues, flowing in different directions from the volcanic summit, experienced a significant advance; a state that was still apparent in January 2009, however in an ASTER satellite image of October 2010, the advance seems to have stopped. Overall, the sudden advance produced a mean change in length since 2007 of 234 $\pm$ 49 m. In order to study this glacier behavior and a possible connection to the ongoing eruption of nearby Volcán Chaitén, an airborne laser system (CAMS) designed and built by CECS, was used to map several profiles at the volcano in 2009, yielding a high precision surface topography of the area. When this laser data were compared to previous DEMs, especially SRTM and a photogrammetrically derived DEM based upon 1961 data, no significant elevation changes were detected at the glacier as a whole mainly due to low quality of the oldest DEM and/or small elevation change signals, however, at the lower part of several glaciers there is a clear thinning trend especially between 1961 and 2000. A new airborne survey is under preparation for repeating some of the surveyed profiles, and detecting possible changes. Another ice-capped active volcano within this region is Volcán Hudson (45º55'S) where the first glacier inventory has been concluded thanks to the use of ASTER satellite images provided by the GLIMS project, totalizing 136 km2 of ice distributed among 26 glacier basins in year 2007. This volcano experienced an explosive eruption in 1991 that destroyed most of the glacier infilling the caldera, provoking huge lahar flows towards the valleys of Glaciar Huemules and Río Ibañez. Several kinds of available DEMs allowed determination of significant ice elevation changes in the last 25 years. In the period between 1974 and 2000, the mean ice thinning yielded 1.8 m a-1. This trend increases to 2.4 m a-1 for the whole period (1974-2009) which is concurrent with a strong retreat of 310 m a-1 (1974-2007) of the main glacier, Glaciar Huemules. Although not being strict indication of the eruption effect of 1991, the enhanced ice thinning and frontal change seem possibly related to this eruptive cycle, which remains one of the largest in Chile during historical times. The first airborne survey of this volcano including a laser and a FLIR (Forward looking Infra-Red) camera is under preparation. The low quality cartography used for the glacier inventory in these remote areas, avoided detection of elevation changes and are misleading when use for glacier basins delineation. In those cases, a laser mapping system together with SRTM can help to improve the surface topography of these poorly known glaciers.