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Historical Glacier and Climate Fluctuations at Mount Hood, Oregon

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Abstract

Terminus fluctuations of five glaciers and the correspondence of these fluctuations to temperature and precipitation patterns were assessed at Oregon's Mount Hood over the period 1901–2001. Historical photographs, descriptions, and climate data, combined with contemporary GPS measurements and GIS analysis, revealed that each glacier experienced overall retreat, ranging from −62 m at the Newton Clark Glacier to −1102 m at the Ladd Glacier. Within this overall trend, Mount Hood's glaciers experienced two periods each of retreat and advance. Glaciers retreated between 1901 and 1946 in response to rising temperatures and declining precipitation. A mid-century cool, wet period led to glacier advances. Glaciers retreated from the late 1970s to the mid-1990s as a result of rising temperatures and generally declining precipitation. High precipitation in the late 1990s caused slight advances in 2000 and 2001. The general correspondence of Mount Hood's glacier terminus fluctuations with glaciers in Washington and Oregon suggests that regional, decadal-scale weather and climate events, driven by the Pacific Decadal Oscillation, play a key role in shaping atmosphere-cryosphere interactions in Pacific Northwest mountains. Deviations from the general glacier fluctuation pattern may arise from local differences in glacier aspect, altitude, size, and steepness as well as volcanic and geothermal activity, topography, and debris cover.

Introduction

Glaciers thicken and advance when accumulation (e.g., snowfall and avalanches) exceeds ablation (e.g., snowmelt and calving); conversely, glaciers thin and retreat under negative mass balance conditions. The termini of small alpine glaciers are especially sensitive indicators of climate change (Menzies, 2002). Ablation season temperature changes of as little as 0.5°C or accumulation season precipitation changes of 10% may be sufficient to alter glacier mass balance (Tangborn, 1980) and ultimately shift termini. Measurable alpine glacier size changes may occur in as few as 1–5 years (Burbank, 1982) to a more decadal scale (Johannesson, 1989; Pelto and Hedlund, 2001; Kovanen, 2003) following climate forcing (Burbank, 1982). Glacier termini measurements have long been used to assess glacier response to climate (Nesje and Dahl, 2000). While lacking the accuracy of mass balance determinations, termini measurements provide a spatially and temporally comparable and economical way to assess glacier-climate relationships (Harper, 1993). Alpine glacier termini may thus be important tools for determining the direction, frequency, and magnitude of past climate change.

North America's Pacific Northwest glaciers have generally receded during the past century, a period characterized by a region-wide temperature rise of ~0.8°C and precipitation increase of approximately 7 cm (JISAO/SMA Climate Impacts Group, 1999). Most such glacier change has been attributed to climate fluctuations; however, glacier aspect, altitude, size, and steepness as well as volcanic and geothermal activity, accumulation area, topography, and debris cover can complicate a direct response to climate forcing.

Glaciers on Oregon's Mount Hood (Fig. 1) have been studied since the late 19th century when Hague (1871) recorded the character and extent of the White River, Sandy, and Reid glaciers. Reid (1905, 1906) described the Coe, Eliot, Ladd, Newton Clark, and White River glacier termini in 1901. His termini photographs are a remarkable baseline for 20th century glacier studies at Mount Hood. Gannett (1903) and Sylvester (1908a) further described Mount Hood's early 20th century glaciers. The Mazamas, a Portland, Oregon-based mountaineering organization, began measurements from fixed points to the termini of the Eliot, Ladd, and Coe glaciers in the 1920s (Mazamas Research Committee, 1925, 1927, 1928), and the White River and Newton Clark glaciers in the 1930s (Phillips, 1935). Termini measurements continued until 1946 (Phillips, 1946). The Mazamas Research Committee (MRC) also contracted for oblique aerial photographs of Mount Hood's glaciers in 1935, 1938, 1946 and 1956 (Mazamas Research Committee, 1935, 1938, 1946, 1956). Ice volume mapping (Driedger and Kennard, 1986), cross-section and mass balance measurements (Mason, 1954, 1955, 1957; Handewith, 1959; Dodge, 1964, 1971, 1987), superglacial debris analysis (Lundstrom, 1992, 1993), and moraine mapping and dating (Lawrence, 1948; Lillquist, 1988) have shed further light on Mount Hood's post-Pleistocene glaciers.

This paper addresses two questions: (1) how did Coe, Eliot, Ladd, Newton Clark, and White River glacier termini fluctuate between 1901 and 2001; and (2) how did these fluctuations correspond to Mount Hood's temperature and precipitation patterns?

Study Area

Mount Hood, at 3426 m, is the highest summit in Oregon and the fourth highest mountain in the Cascade Range. Quaternary andesite and dacite lavas and interbedded pyroclastic debris compose this stratovolcano (Wise, 1969; White, 1980). Collapsing lava domes formed pyroclastic flows on Mount Hood's south flanks, ash plumes that drifted downwind, and lahars that extended far down valleys radiating from the mountain (Crandell, 1980; Cameron and Pringle, 1986, 1987). Crater Rock (Fig. 1) has been the focus of historic geothermal and minor eruptive activity (Sylvester, 1908a; Phillips and Collins, 1935).

Mount Hood's mid-latitude location atop the north-trending Cascade Range, approximately 160 km inland of the Pacific Ocean and the Coast Range, plays a strong role in its climate patterns. Temperatures are generally lower and precipitation is typically higher

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