Remote Sensing Risk Assessment of Valdez Glacier Lake

Erik Soederstroem, Department of Geography, University of Alaska Fairbanks

Introduction

One of the most observable impacts of a warming climate is the retreat of alpine glaciers worldwide. As glaciers retreat, pro-glacial lakes are often formed between the retreating ice and an impounding terminal moraine. Many of these newly formed glacial lakes are unstable and can experience outburst floods that are threatening to downstream communities and infrastructure (Bajracharya et al. 2011). A moraine dam may fail due to internal weakening of the dam itself, due to ablation of ice within the moraine (Richardson & Reynolds 2000), or it may fail due to some external trigger such as displacement waves, earthquakes, upstream floods from ice dammed or supra-glacier lakes (Shrestha 2008), or heavy rainfall events (Narama et al. 2009). A single glacial outburst flood event can cause devastation costing hundreds of millions dollars as well as loss of human lives. A risk assessment can provide important information for decision-makers in order to carry out proper planning, legislation and adaptation strategies (Shrestha et al. 2010, McKillop & Clague 2007). This study is a first risk assessment on the Valdez Lake, and an attempt to better understand the possible hazard to the community of Valdez, AK.

Study Area

Valdez Glacier Lake is a moraine-dammed lake located at the terminus of the Valdez Glacier. The lake is located at 41° 09’10” N and 146° 08’20” W, at an elevation of 60 meters above sea level, 10 km north east from the city of Valdez. The average annual total precipitation of Valdez is 2,712.2 mm, with extreme events of over 300 mm precipitation per day possible (The Alaska Climate Research Climate Center). The geology around Valdez is dominated by Sedimentary rocks such as litharenite sandstone and argillite. (Kochelek et al. 2011) The Valdez region is also in an earthquake prone area (The Alaska Climate Research Climate Center) with extreme events of over 100 mm precipitation per day (Kochelek et al. 2011). The Valdez region is also in an earthquake prone area (The Alaska Climate Research Climate Center). The study area extends from 1950 to 2006. The development of Valdez Glacier Lake over time was determined by measuring the lake outburst flood.

Methods

The development of Valdez Glacier Lake over time was determined by making comparisons between a 1950 aerial photgraph, a 1978 aerial photograph, a 1995 LANDSAT 5 image, and a 2010 SPOT 5 image. Changes in lake surface area were measured by digitizing lake shorelines and position of the calving terminus of the Valdez Glacier. The lake is located at 61° 20’38” N and 146° 08’20” W, at an elevation of 60 meters above sea level, 10 km north east from the city of Valdez. The average annual total precipitation of Valdez is 2,712.2 mm, with extreme events of over 300 mm precipitation per day possible (The Alaska Climate Research Climate Center). The geology around Valdez is dominated by Sedimentary rocks such as litharenite sandstone and argillite. (Kochelek et al. 2011) The Valdez region is also in an earthquake prone area (The Alaska Climate Research Climate Center) with extreme events of over 100 mm precipitation per day (Kochelek et al. 2011). The Valdez region is also in an earthquake prone area (The Alaska Climate Research Climate Center). The study area extends from 1950 to 2006. The development of Valdez Glacier Lake over time was determined by measuring the lake outburst flood.

Results

Glacier retreat and lake change

Valdez Glacier has retreated almost 1.9 km during the last 60 years, resulting in the formation of Valdez Glacier Lake. This lake was not present in 1950, but has grown to an area of 1.8105 km² as of 2010.

Outburst Probability

Thermokarst collapse features and the formation of kettle lakes observed in the 2006 USGS DEM (Figure 3) and aerial photos indicate that the moraine is partly ice-cored, that the ice is melting, and that the moraine surface and subsurface is unstable (Figure 4). An outburst flood probability model developed by McKillop & Clague (2007) returns a percent probability of 16.0% for a frozen ice-cored moraine, which is considered "medium probability" (2-18%) of outburst. For a half ice-cored moraine (Figure 4), the probability was 4.1%, and to 70.5% for ice-melt moraine. The latter two are both considered to have a "very high probability" risk of outburst flood.

Conclusions

• Valdez Glacier has retreated almost 1.9 km during the last 60 years.
• Valdez Glacier Lake has grown to an area of 1.8105 km² as of 2010.
• Ice-melt collapse features and incipient kettle lakes indicate the moraine to be partly ice-cored and the ice is melting.
• Several areas of moraine dam subsurface ice melt and collapse were observed to have occurred between 1950 and 2006.
• Estimated outburst probability: 16.0% for ice-cored moraine, 4.1% for half-ice-cored moraine, and 70.5% for ice-melt moraine.
• The volume for Valdez Glacier Lake was estimated to be ~80,003,310 m³. Peak discharge volumes for each of the modeled dams was estimated to be: moraine dam - 6654 m³/s, landslide dam - 2928 m³/s, "worst case" - 15694 m³/s.
• Outburst flood discharge rates are estimated for moraine dam, landslide dam and 'worst case' discharge values at 6654 m³/s, 2928 m³/s,  and 15694 m³/s respectively. Former channels may provide new pathways for outburst flood waters.

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References


