Goals of the Project

1. To extract DEMs and orthophotos from aerial photographs from two different data sets, 1979 & 1990

2. Subtract these DEMs from the 2010 LiDAR DEM to determine the spatial distribution of volume change and to obtain a volume change estimate.
Collier Glacier & Three Sisters Volcanoes

- Volcanoes located 25 miles west of Bend, Oregon
- Three Volcanoes all over 3060 meters in elevation
- 14 named glacier with Collier being the largest
- Collier - North aspect glacier between Middle and North Sister
- Most studied glacier on the volcanoes

Glacier outlines are from the 1:24,000 USGS quadrangle from 1957

Qualitative Repeat Photography

Photo R. Simms
Photo Weiprecht USGS
Data

<table>
<thead>
<tr>
<th>Image/DEM Name</th>
<th>Type</th>
<th>Date</th>
<th>Source</th>
<th>Resolution</th>
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<td>LiDAR_DEM</td>
<td>DEM</td>
<td>2010</td>
<td>DOGAMI</td>
<td>1 meter</td>
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**Methods & Error Analysis**

- **Software**
  - ERDAS LPS
    - Orthorectification and DEM creation
  - ArcGIS
    - Volume change analysis
      - Hillshade
      - Raster math
      - Cut and fill
      - Longitudinal profiles
- **Triangulation (RMSE)**
  - 1979
    - 1.616 pixels
  - 1990
    - 1.479 pixels
- No tie points were used if on glacier surface.
- GCP were selected from 2005 NAIP Orthorectified Imagery and 2010 LiDAR DEM
- 5 meter resolution for all DEMs
Orthorectified Photographs

1979 Orthophoto

1990 Orthophoto

1979 Orthorectified Photo draped over 1979 DEM
1990 Orthorectified Photo draped over 1990 DEM

1979 hillshade with 1979 glacier perimeter
1990 hillshade with 1990 glacier perimeter

2010 LiDAR hillshade with
- 2010 terminus estimate,
- 1979 glacier perimeter, and
- 1990 glacier perimeter
Thickines Change
Longitudinal Profile

Spatial Distribution of Volume Change

<table>
<thead>
<tr>
<th></th>
<th>$\Delta$ Volume (km$^3$)</th>
<th>$\Delta$ Volume (km$^3$)</th>
<th>Normalized Height Change (m)</th>
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<tbody>
<tr>
<td></td>
<td>Total Glacier</td>
<td>Ablation Zone</td>
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<td>1979 to 1990</td>
<td>0.0068</td>
<td>0.0033</td>
<td>6.32</td>
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<tr>
<td>1979 to 2010</td>
<td>-0.0021</td>
<td>-0.0029</td>
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<td>1990 to 2010</td>
<td>-0.0088</td>
<td>-0.0061</td>
<td>-8.37</td>
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Conclusion and Discussion

• 1979 DEM was not trusted
• $\Delta$Volume from 1990 to 2010 was -.0088km$^3$ which equates to a 8.37 meter drop across the glacier.
• Ablation zone of the glacier showed most volume change
• Accumulation zone elevation should be roughly the same height over time except for seasonal snow changes
• Error analysis needs to be conducted by comparing bedrock points

Questions?