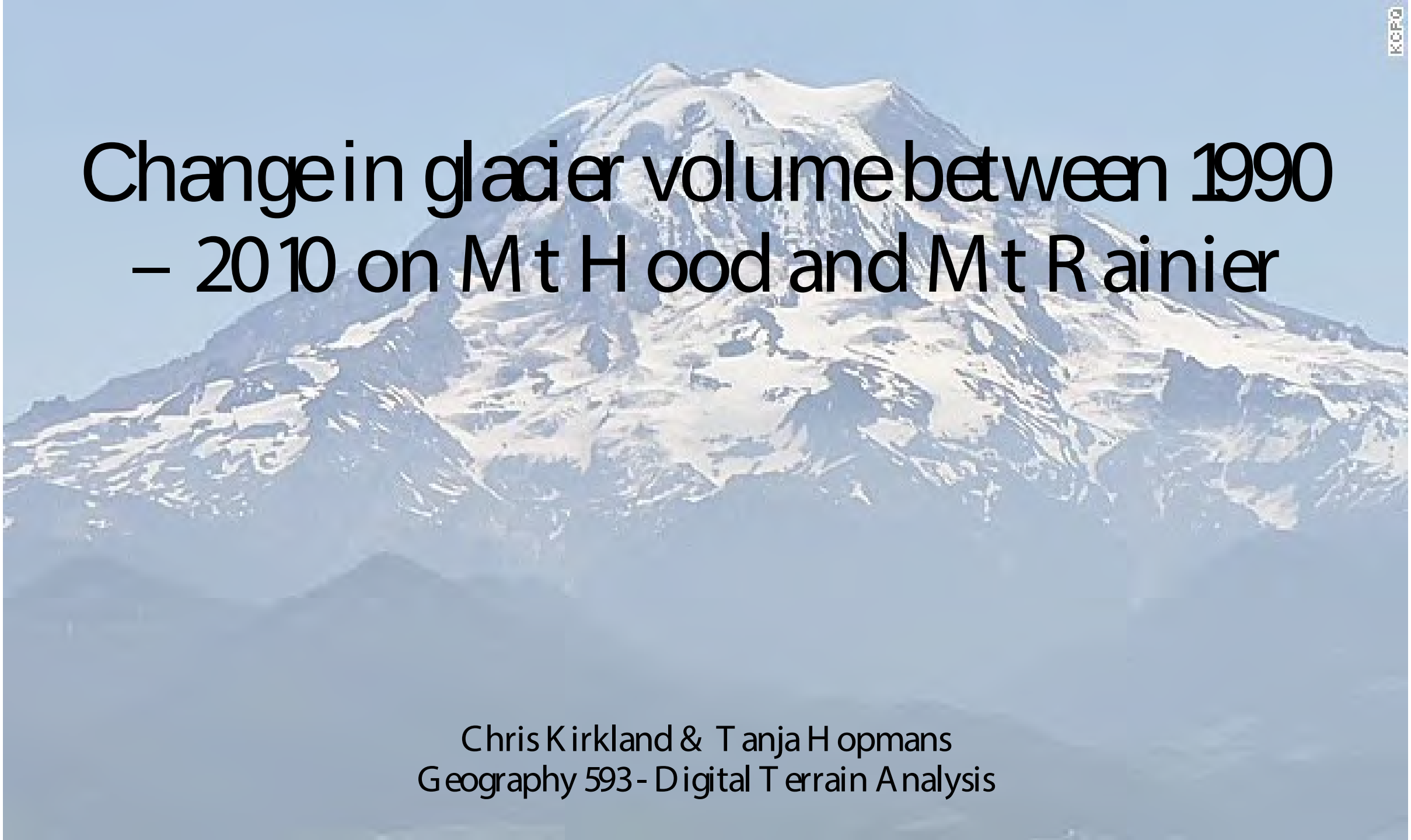


# Change in glacier volume between 1990 – 2010 on Mt Hood and Mt Rainier

Chris Kirkland & Tanja Hopmans
Geography 593 - Digital Terrain Analysis

# Introduction & Background

- Glaciers provide tangible evidence of climate change and act as a measureable and quantifiable source of the effects of rising temperatures and changes with weather patterns

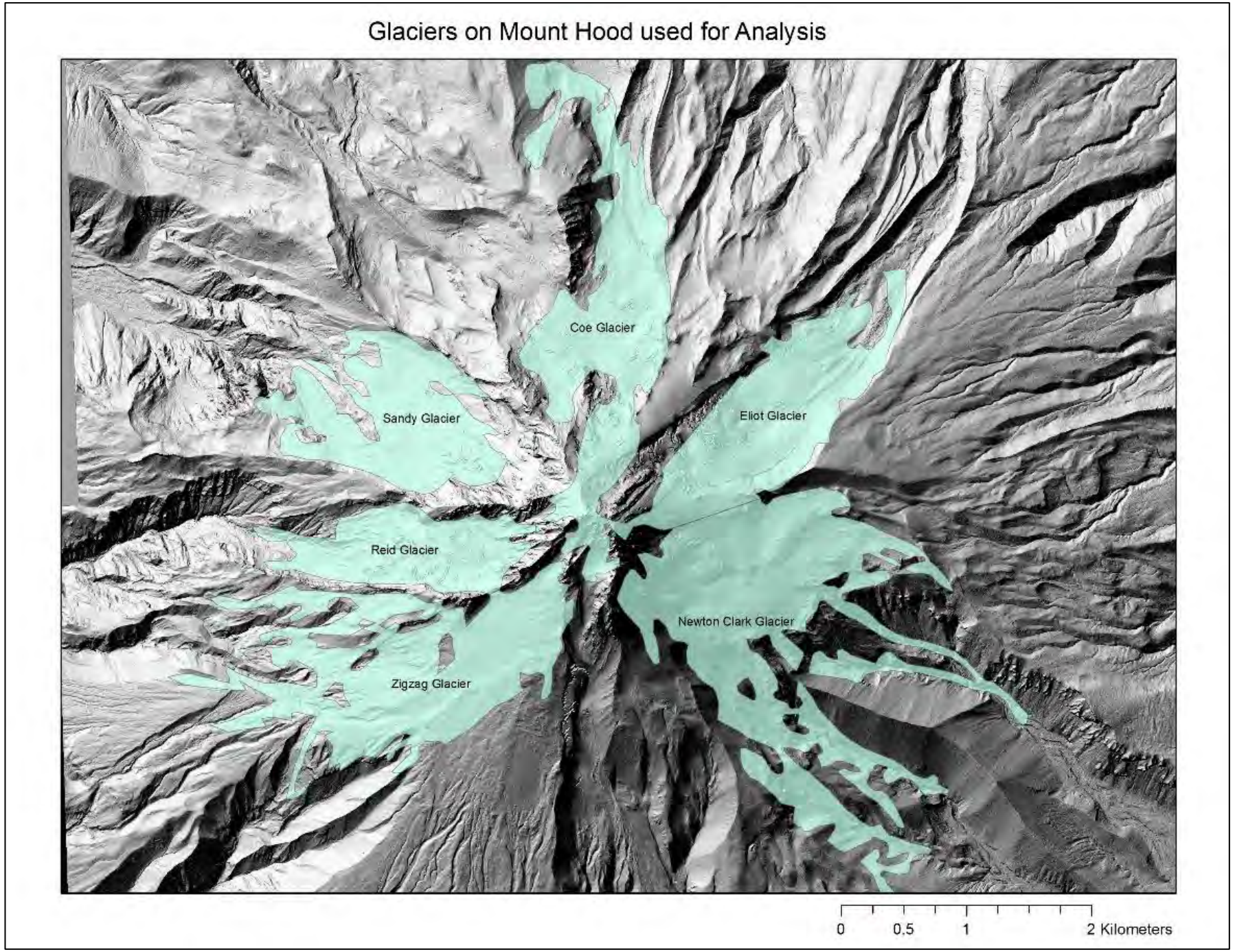
- Use of historic and current DEMs to measure and quantify ice volume depletion and use of models to calculate rate of retreat and draw correlations to influential factors

- Multiple studies have shown that DEMs can be used to accurately quantify glacial ice loss and glacier surface elevation change (Sisson 2011 & McNabb 2012)

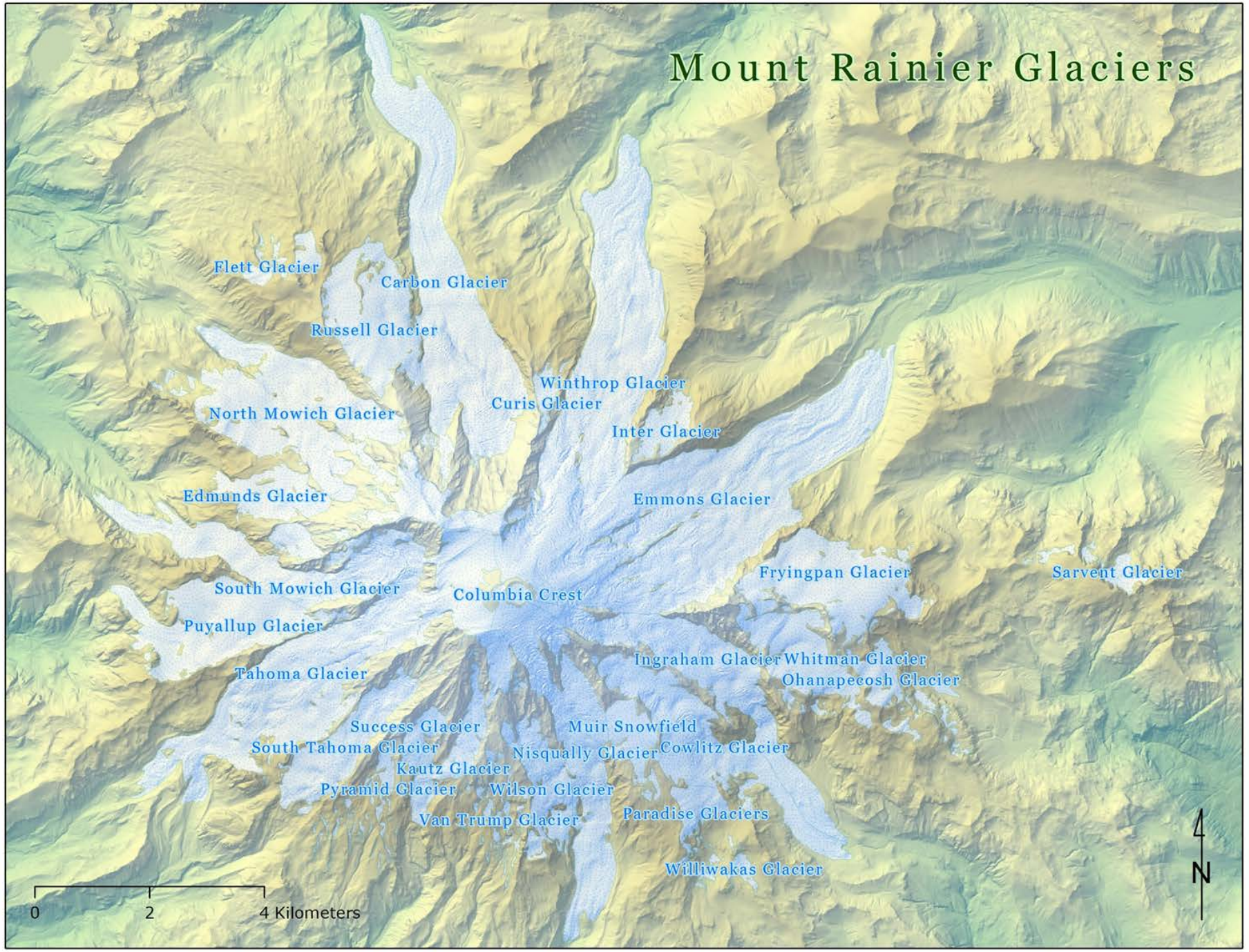
# Datasets

- 1:100,000 Scale - All North American Glacier Outlines
  - DRG / DLG / USGS Topo Map derived
  - Limited accuracy at large scale and from area to area
- 1:5,000 Scale - Mount Rainier Glacier Outline file
  - Lidar derived, higher accuracy for Rainier study area required due to resolution
- 1970 - 1990 Historic DEM for Mount Rainier Study Area
  - 10 meter horizontal and 1meter vertical accuracy
- 2006 DEM for Mount Rainier Study Area
  - 1meter horizontal and 1meter vertical accuracy
- 1990 Historic DEM for Mount Hood Study Area
  - 30 meter horizontal and 1meter vertical accuracy
- 2010 DEM for Mount Hood Study Area
  - 3foot horizontal and 1foot vertical accuracy

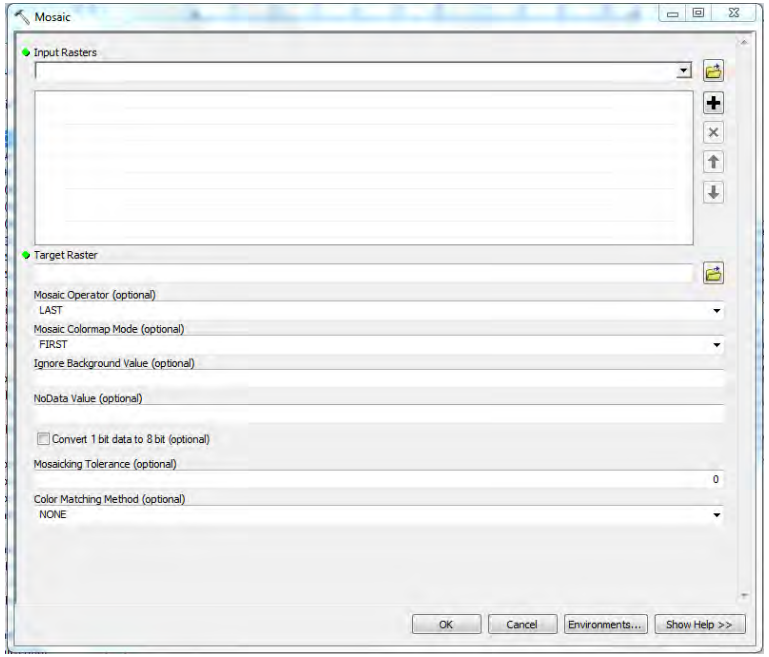
# Mount Hood Study Area

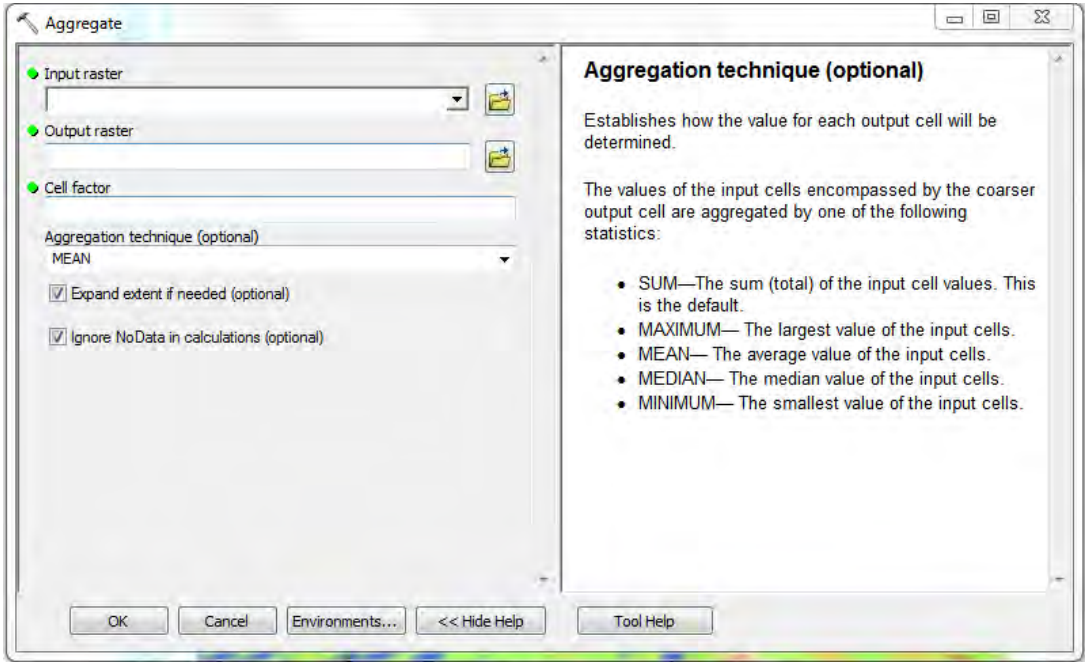


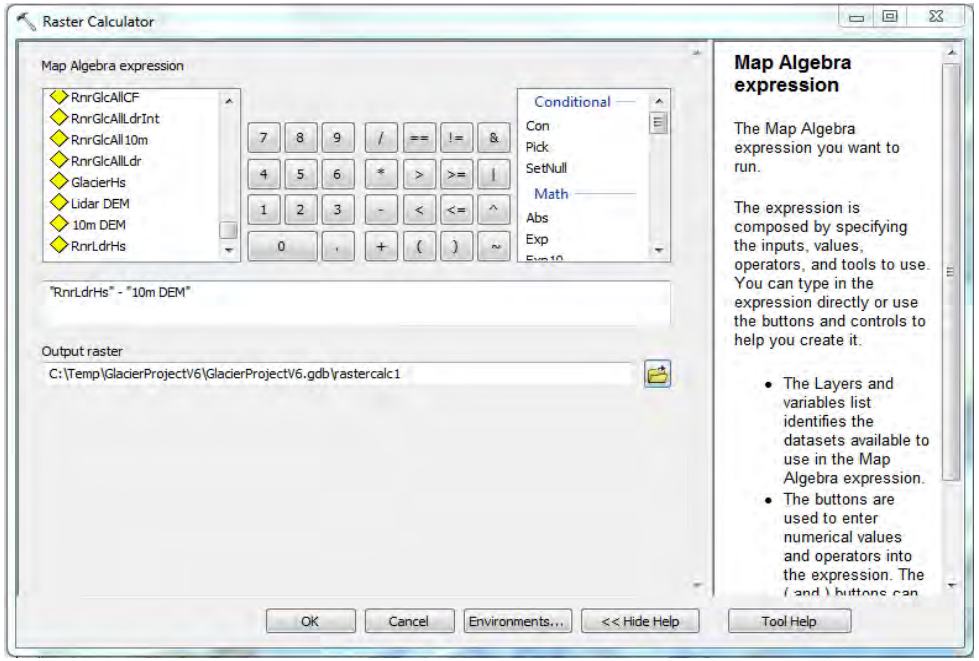
# Mount Rainier Study Area

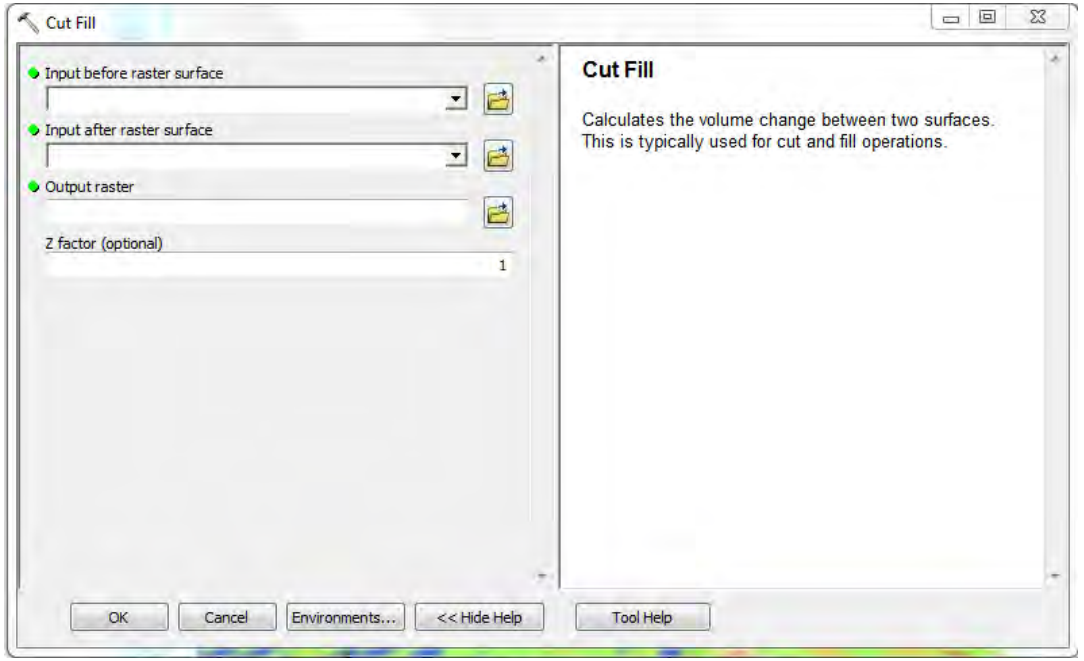


# Methods & Tools



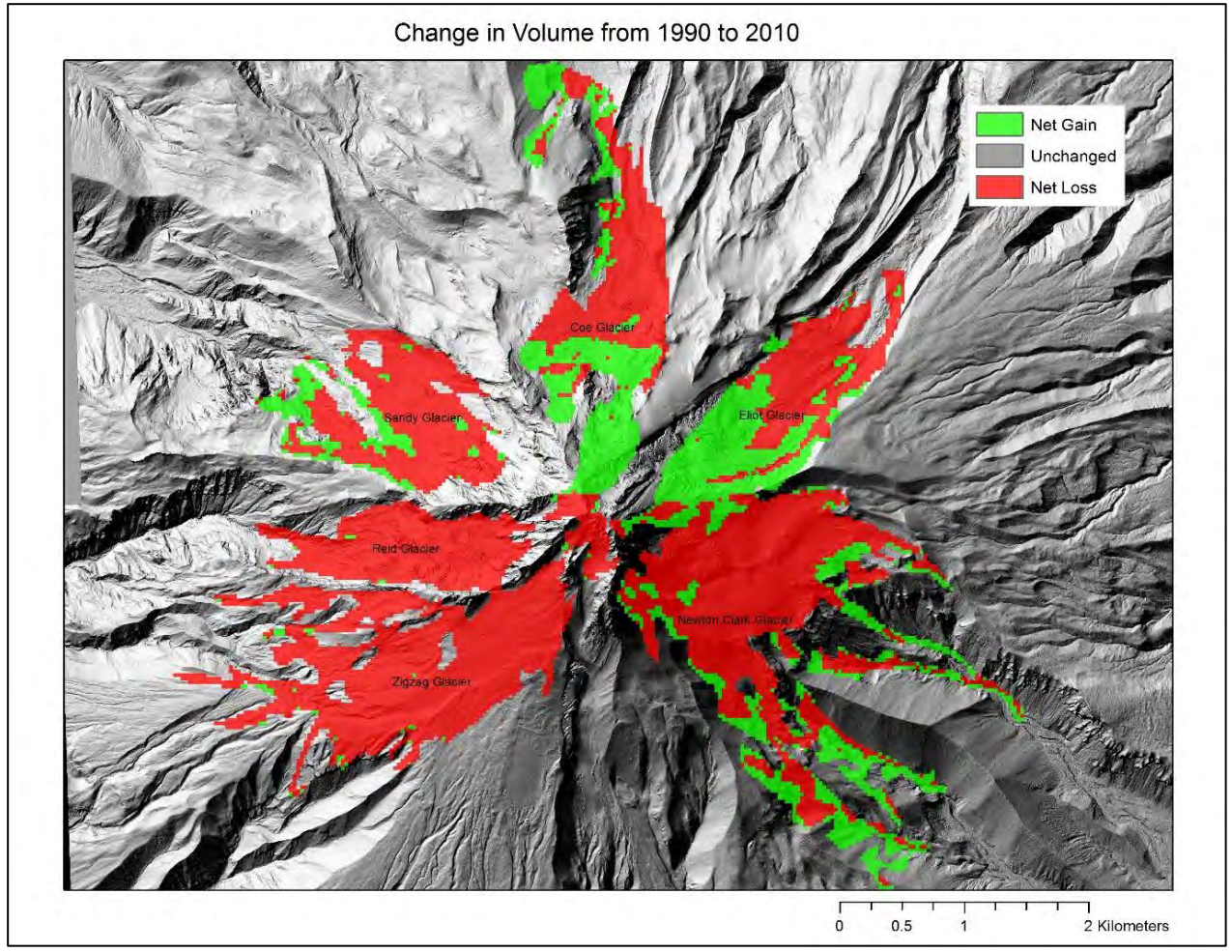



# Methods & Tools

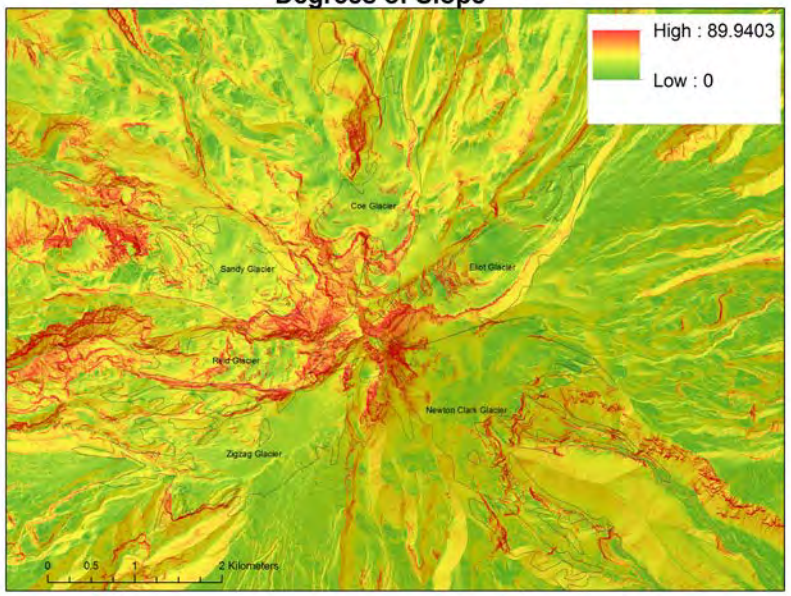
- Mosaic DEMs together to create seamless study area
- Use glacier shapefile to extract / clip out data for all glaciers as well as individual glaciers
- Use Aggregate tool to convert to matching linear units between DEMs
- Use Raster snap function to align datasets
- Use Cut Fill to analyze volume increase, decrease and sum
- Use Raster calculator to determine height change over glacier surface
- Use Raster calculator to elevation units
- Use summary statistics and attribute table statistics to determine volume sum, increase, decrease and area

# Results for Mount Hood Study Area

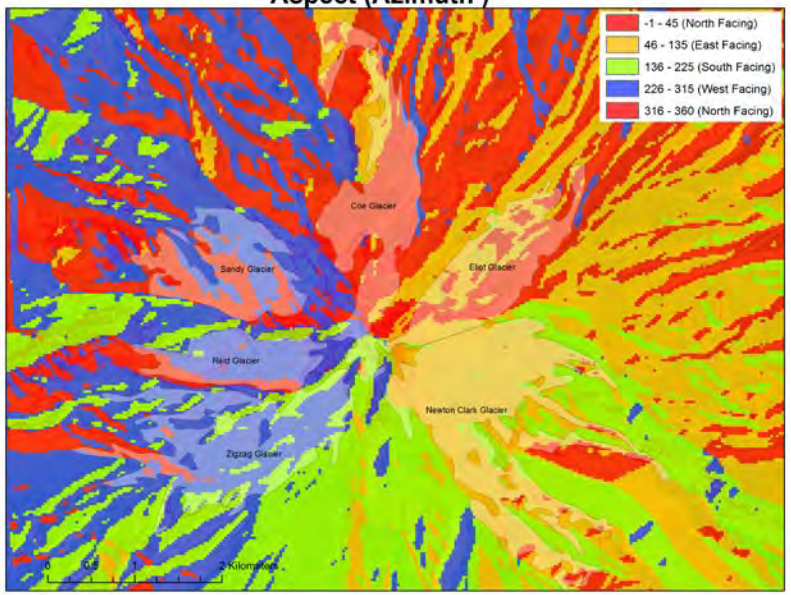



| Glacier | Volume decrease ($km^3$) | Volume increase ($km^3$) | Net Change ($km^3$) | Area ($km^2$) | aspect |
|---|---|---|---|---|---|
| Eliot | 0.00798 | 0.01023 | +0.0022442 | 1.64694 | North and east facing |
| Sandy | 0.01243 | 0.00166 | -0.010765 | 1.41192 | West and north facing |
| Newton Clark | 0.03324 | 0.00677 | -0.026461 | 3.31729 | East facing |
| Zigzag | 0.03613 | 4.506239e-5 | -0.036087 | 2.34930 | West and south facing |
| Coe | 0.01505 | 0.01133 | -0.0037218 | 2.08816 | North facing |
| Reid | 0.03074 | 3.085552e-5 | -0.030716 | 0.990507 | West and north facing |

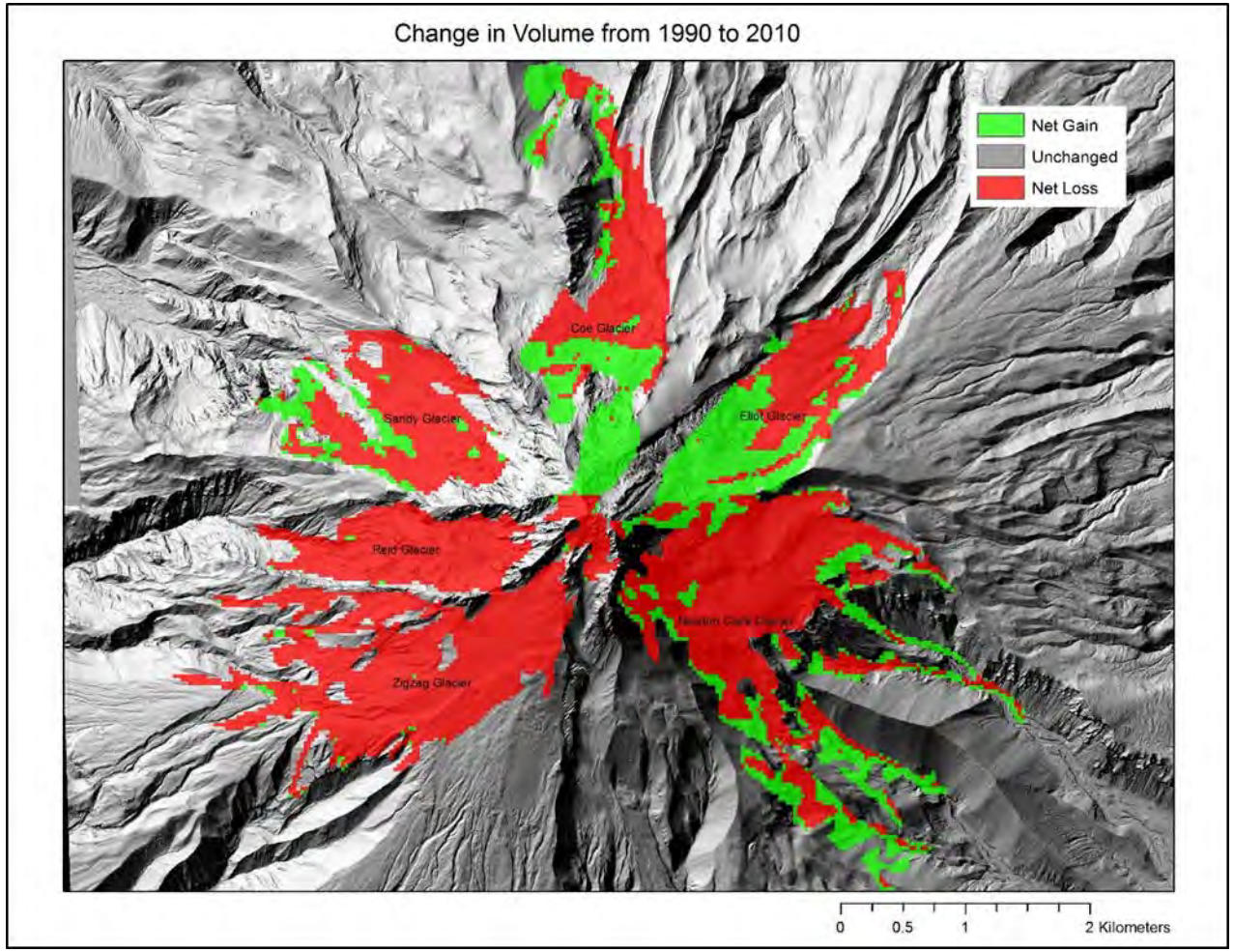
## Degrees of Slope



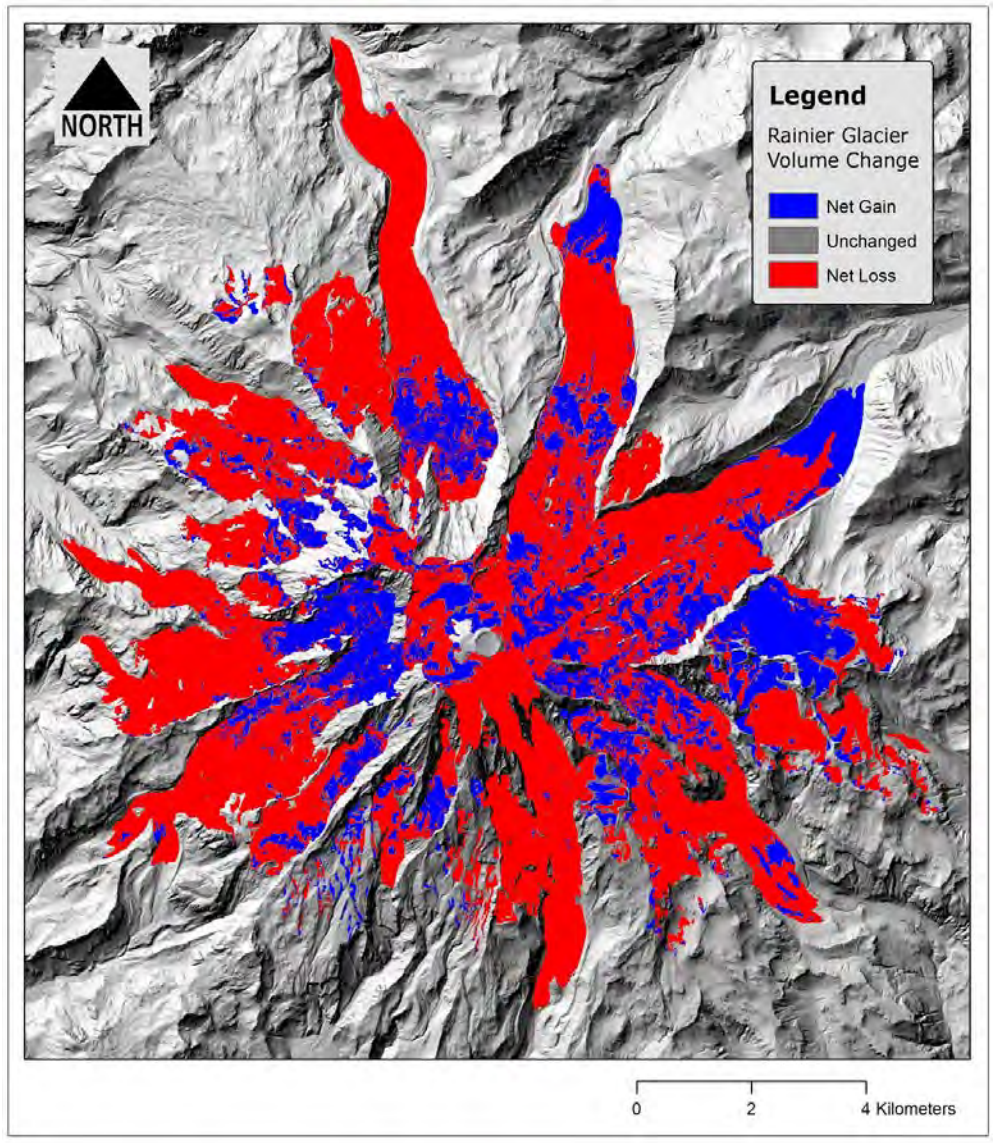

## Aspect (Azimuth )




## Change in Volume from 1990 to 2010



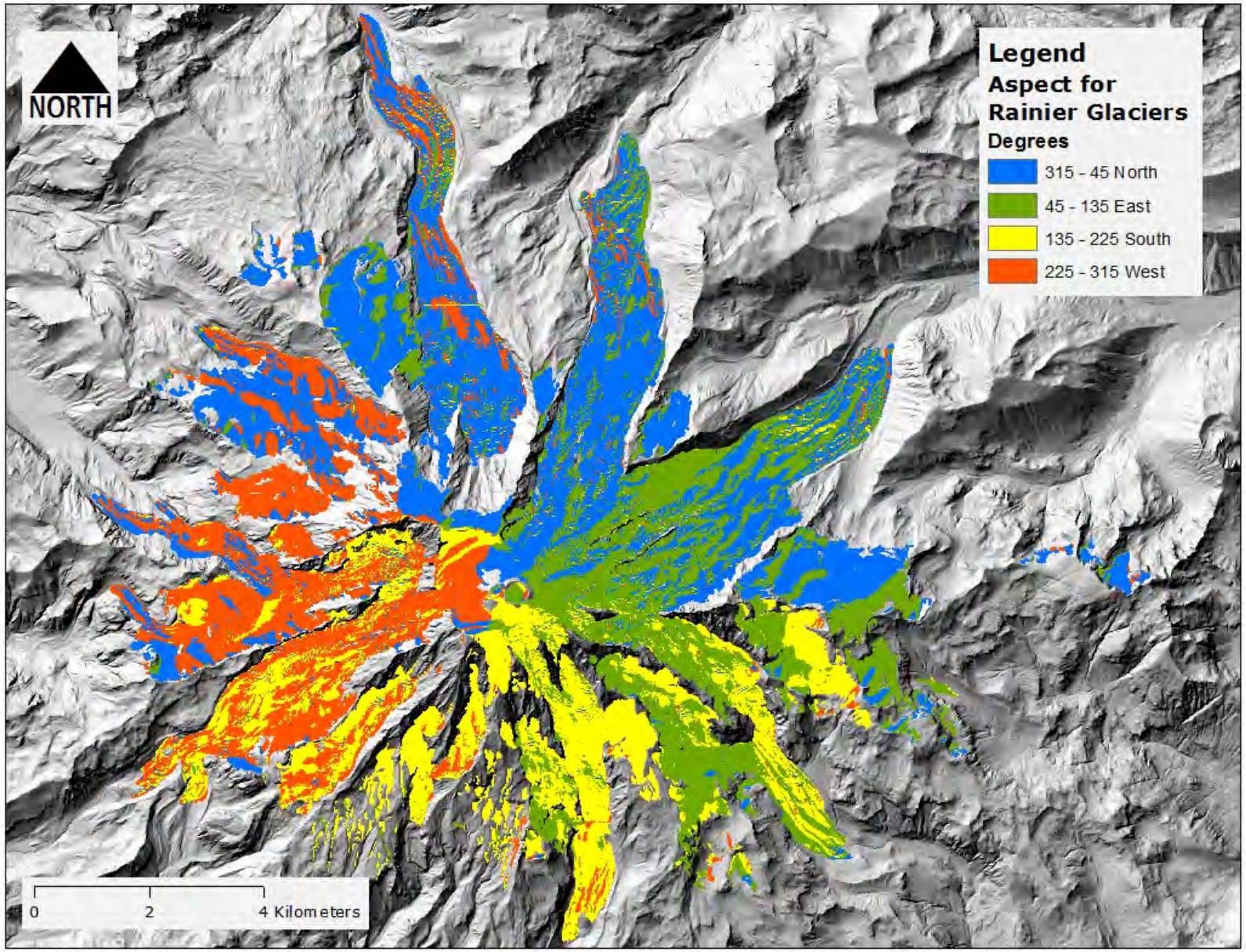
# Results for Mount Rainier Study Area




| Glacier Name (with generalized aspect) | Volume decrease ($m^3$) | Volume increase ($m^3$) | Glacier Volumes ($km^3$) | Glacier Volumes Sum ($m^3$) | Area ($m^2$) | Volume Change ($km^3$) (Sisson 2011) |
|---|---|---|---|---|---|---|
| Carbon N by NW | -7887100 | 100222700 | -0.0923356 | 92335600 | 8415000 | -0.0979 |
| Winthrop N | -18583400 | 62810000 | -0.0442266 | 44226600 | 8996100 | -0.0243 |
| Emmons NE | -49304200 | 55985300 | -0.0066811 | 6681100 | 11252200 | 0.0138 |
| North Mowich W by NW | -5885500 | 41759300 | -0.0358738 | 35873800 | 5624300 | -0.0553 |
| South Mowich W | -15271500 | 25431700 | -0.0101602 | 10160200 | 4209600 | -0.0304 |
| Ingraham SE | -6244600 | 26947500 | -0.0207029 | 20702900 | 3760200 | -0.0279 |
| Cowlitz SE | -2866500 | 29076500 | -0.02621 | 26210000 | 3577100 | -0.0314 |
| Tahoma SW | -13898600 | 57767800 | -0.0438692 | 43869200 | 7663300 | -0.0833 |
| Nisqually S | -191800 | 71207200 | -0.071015400 | 71015400 | 4243700 | –0.0935 |
| Total for all Glaciers | -144755400 | 641467200 | -0.4967118 | -496,711,800 | 81669300 | -0.59 to -0.64 |

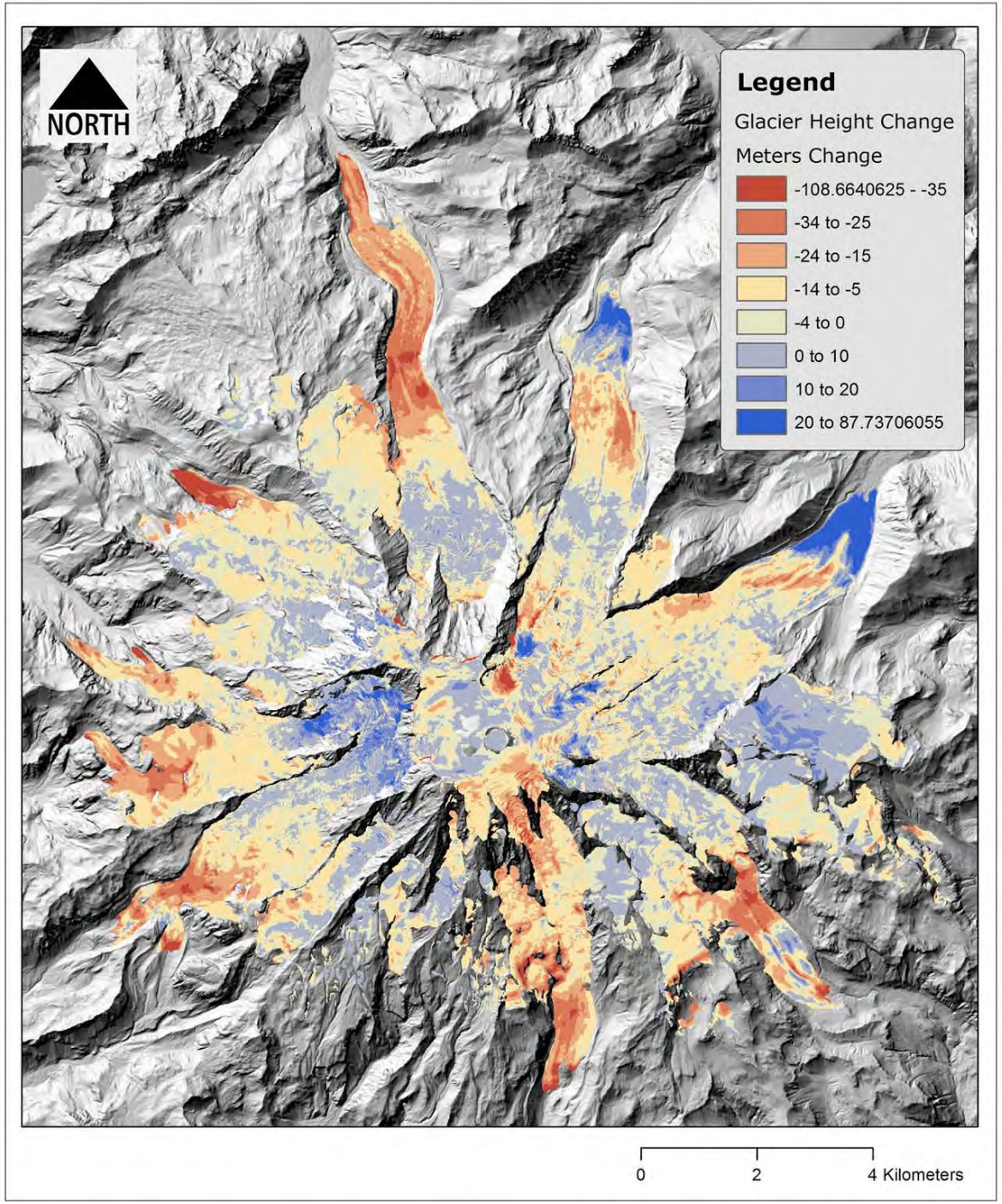
Volume Total for Sisson variation due to original DEM error factor

# Aspect Mount Rainier Study Area



# Results for Mount Rainier Study Area

## Height Change

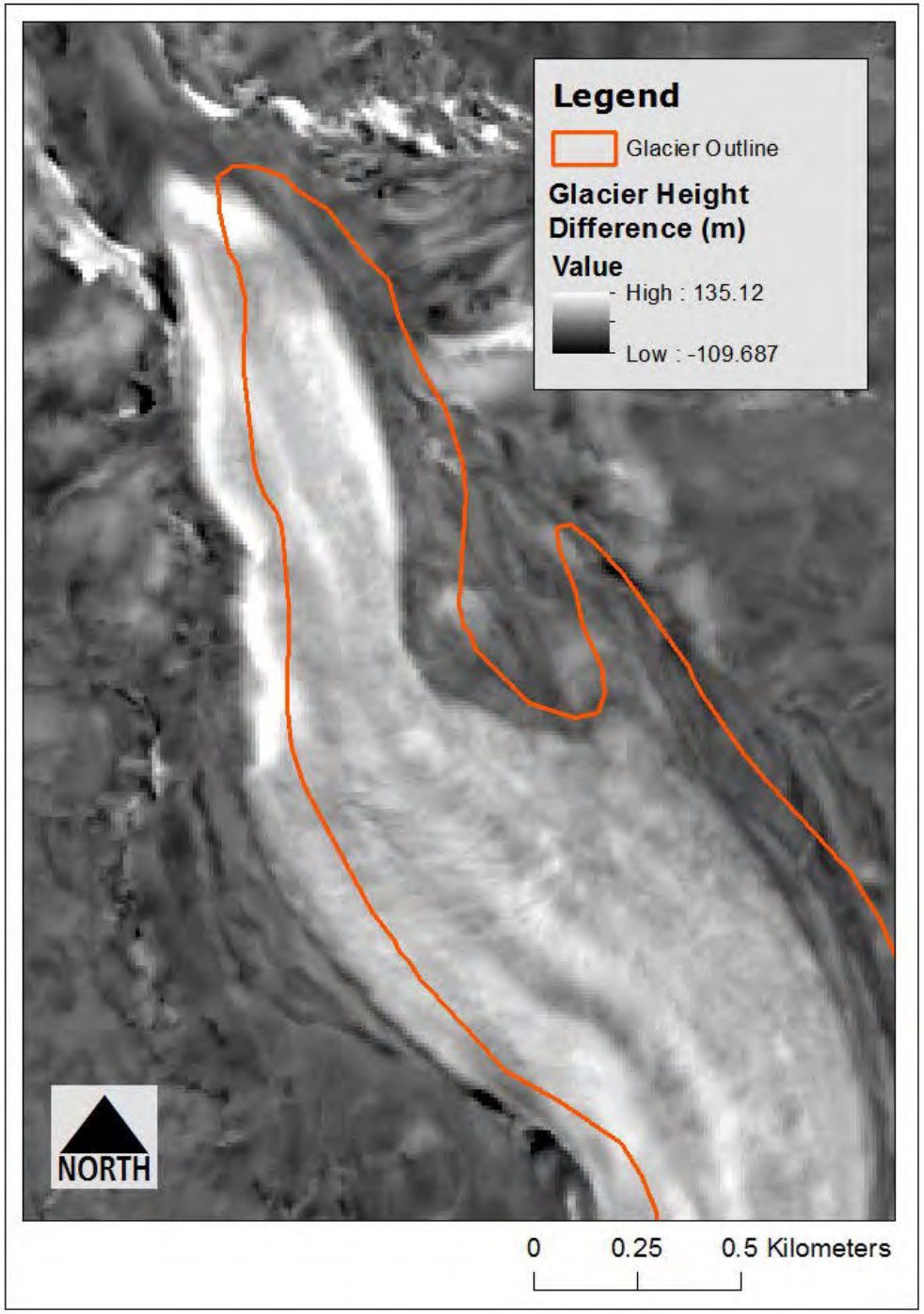


# Limitations and Further Research

- The accuracy of the 'historic' 10m DEMs of Mount Rainier is uncertain since metadata did not include accuracy or error definition or even exact year of acquisition
- Accuracy of 1:100,000 k North American Glacier outline shapefile
- Accuracy of 30 meter DEM and omission of surface details in dataset
- Limited availability of temporal datasets to create multiple analyses and make comparisons
- Possible use of oldest available / accurate aerial photographs from specific years to create additional historic DEMs

1:100,000 k
Glacier
Outline Shapefile
Misalignment

Carbon Glacier
Mount Rainier



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23 August 2010

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1U.S. Geological Survey, 345 Middlefield Road, Menlo Park, California 94025, USA
2 National Park Service, Mount Rainier National Park, Ashford, Washington 98304, USA

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