# Change in glacier volume between 1990 – 2010 on Mt H ood and Mt R ainier

Chris Kirkland & Tanja Hopmans Geography 593 - Digital Terrain Analysis

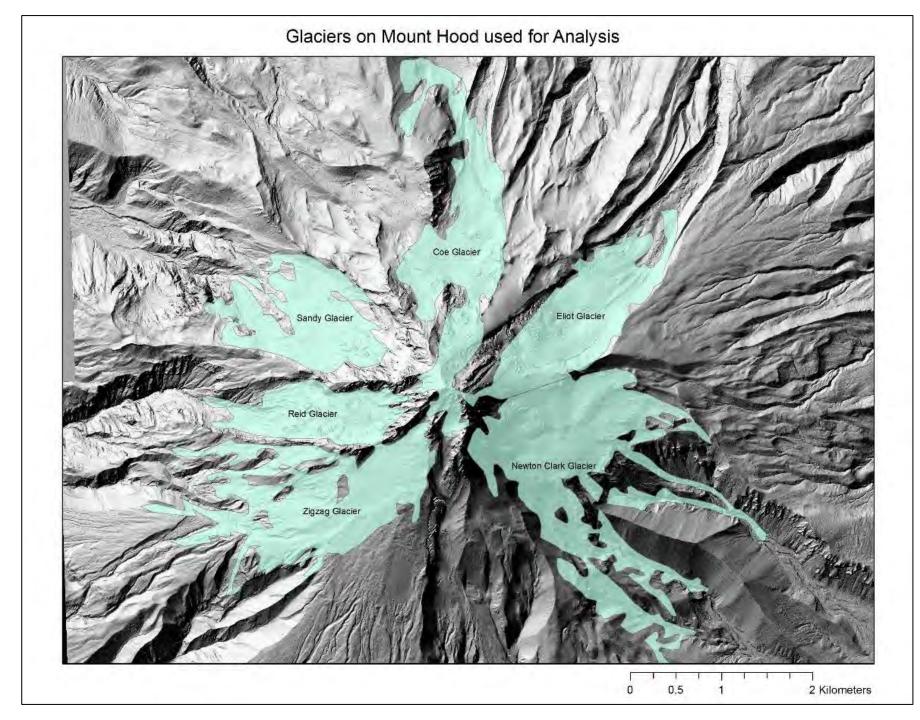
## Introduction & Background

- 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 & McN abb 2012)

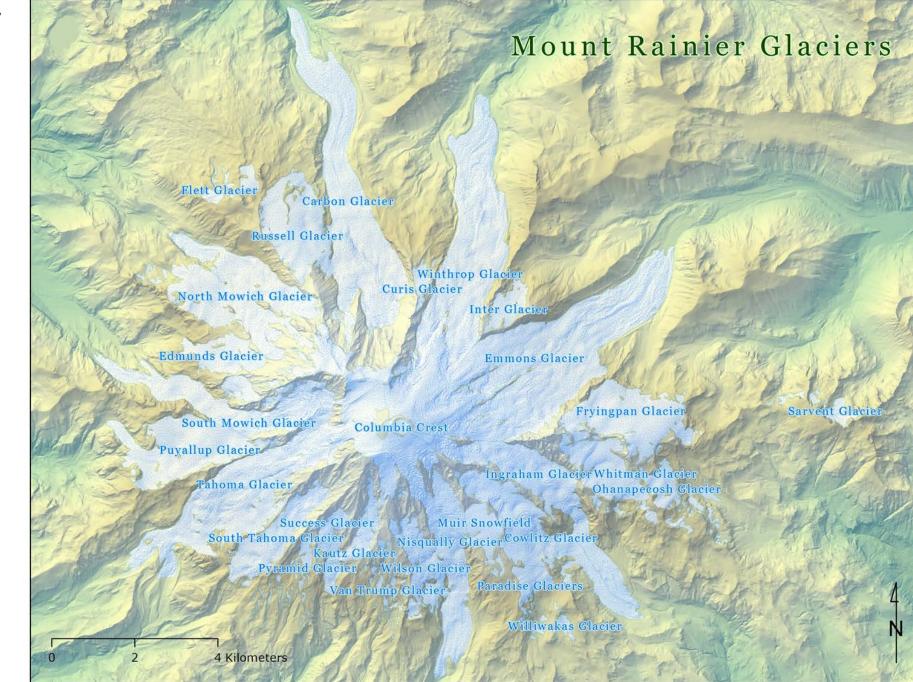
#### Datasets

- 1:100,000 Scale All North American Glacier Outlines
  - DRG / DLG / USGSTopo Map derived
  - Limited accuracy at large scale and from a reato area
- 1:5,000 Scale-Mount Rainier Glacier Outlinefile
  - 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 1 meter 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 1 meter 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

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output raster		Projec	tV6.ge	db∖rast	ercalc 1	í.					You can type in the expression directly or use the buttons and controls to help you create it. • The Layers and variables list identifies the

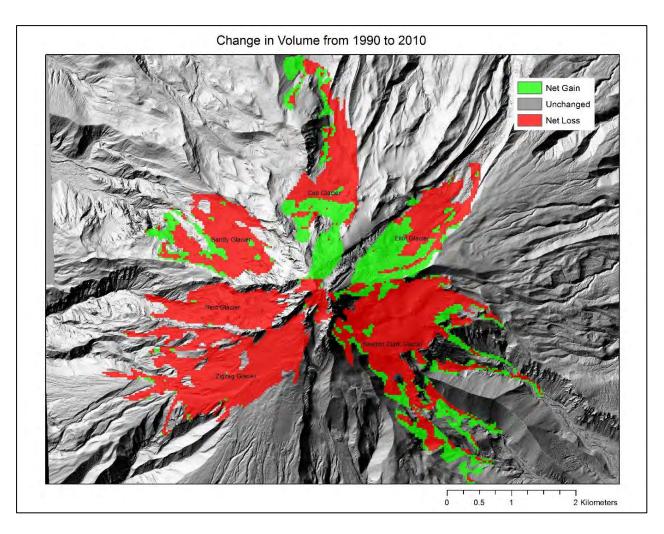
nput raster	Aggregation technique (optional)
Nutput raster	Establishes how the value for each output cell will be determined.
ell factor ggregation technique (optional) MEAN	<ul> <li>The values of the input cells encompassed by the coarser output cell are aggregated by one of the following statistics:</li> <li>SUM—The sum (total) of the input cell values. This is the default.</li> <li>MAXIMUM— The largest value of the input cells.</li> <li>MEAN— The average value of the input cells.</li> <li>MEDIAN— The median value of the input cells.</li> <li>MINIMUM— The smallest value of the input cells.</li> </ul>

<ul> <li>Input before raster surface</li> </ul>	Cut Fill	3
Input after raster surface     Output raster     Z factor (optional)	Calculates the volume	e change between two surfaces. for cut and fill operations.

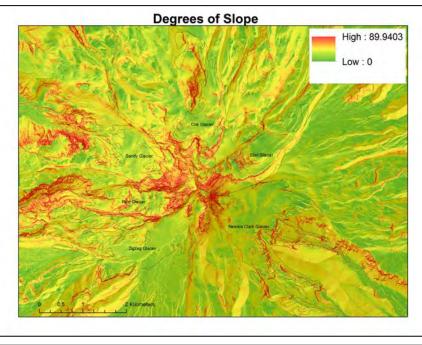
#### Methods & Tools

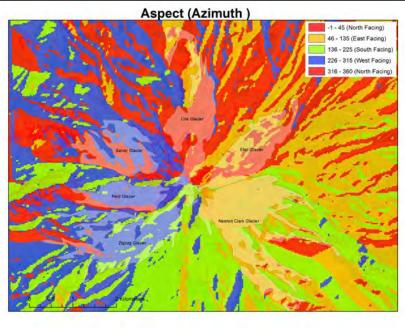
- •Mosaic DEM stogether to create seamless study area
- •Useglacier shapefile to extract / dip out data for all glaciers as well as individual glaciers
- •Use Aggregate tool to convert to matching linear units between DEMs
- •Use Raster snap function to align datasets
- •UseCut Fill to analyze volume increase, decrease and sum
- •Use Raster calculator to determine height change over glacier surface
- •Use Raster calculator to devation units
- •U se summary statistics and attribute table statistics to determine volume sum, increase, decrease and area

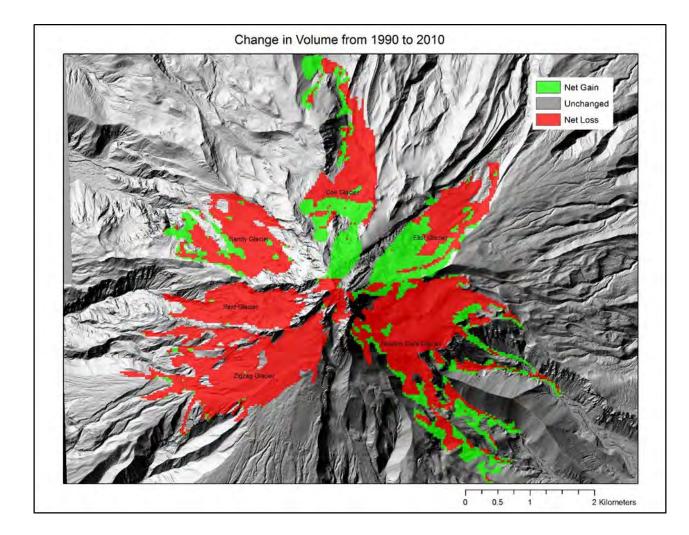
### Results for Mount Hood Study Area



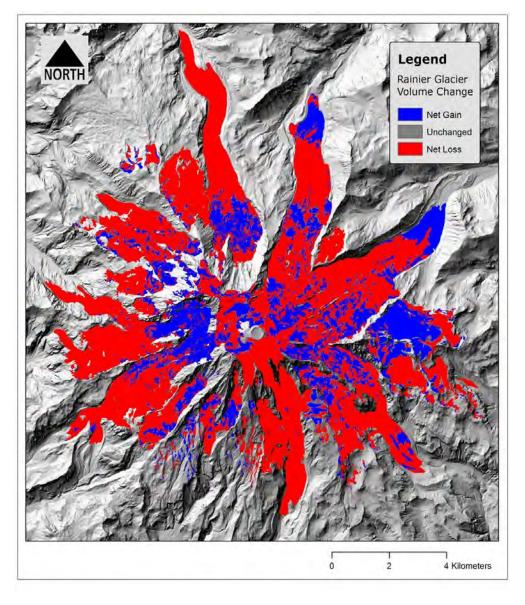
Glacier	Volume decrease (km <sup>3</sup> )	Volume increase (km <sup>3</sup> )	Net Change (km <sup>3</sup> )	Area (km <sup>2</sup> )	aspect
Eliot	0.00798	0.01023	+0.0022442	1.64694	North and east facing
Sandy	0.01243	0.00166	-0.010765	1.41192	West and north facing
Newton Clark	0.03324	0.00677	-0.026461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







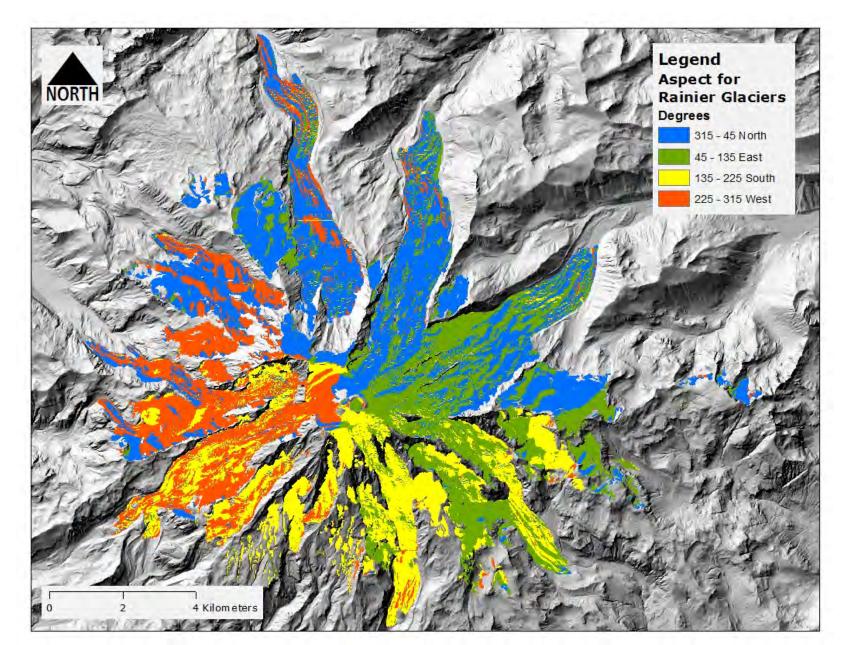
#### Results for Mount Rainier Study Area



Glacier Name (with generalized aspect)	Volume decrease (m³)	Volume increase (m³)	Glacier Volumes (km³)	Glacier Volumes Sum (m³)	Area (m²)	Volume Change (km <sup>3</sup> ) (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

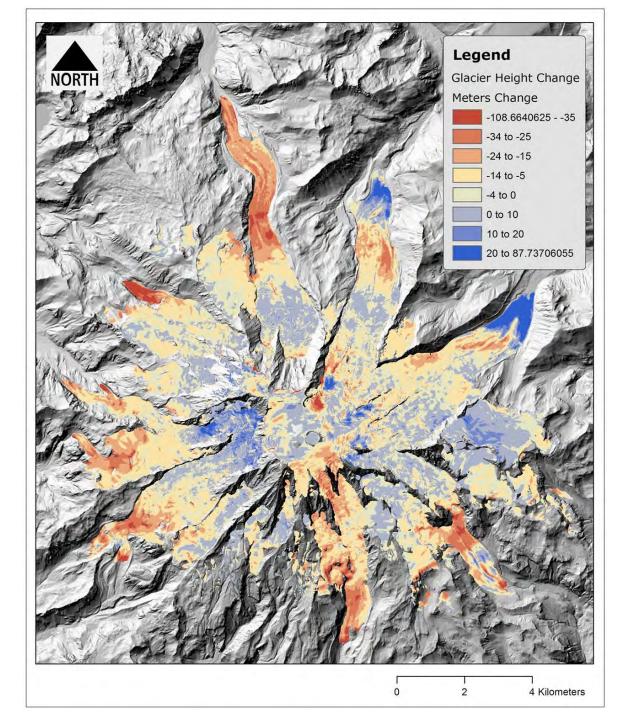
Volume Total for Sisson variation due to original DEM error factor

#### Aspect Mount Rainier Study Area



#### Resultsfor Mount Rainier Study Area

## Height Change

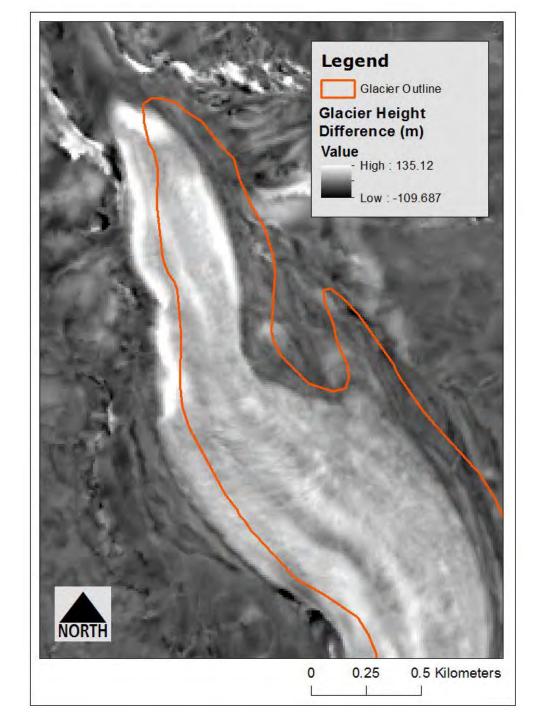


### Limitations and Further Research

- 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
- A ccuracy of 1:100,000 k N orth A merican G lacier outline shapefile
- A ccuracy 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



#### Sources:

P. Peduzzi, C. Herold, and W. Silverio. <u>A ssessing high altitude glacier thickness</u>, volume and area changes using field, GIS and remote sensing techniques: the <u>case of N evado Coropuna (Peru)</u> 23 A ugust 2010

T.W. Sisson 1\*, J.E. R obinson 1\*, and D.D. Swinney 2\* <u>Whole-edifice ice volume change A.D. 1970 to 2007/2008 at Mount R ainier, Washington, based on LiDAR surveying.</u> 1U.S. Geological Survey, 345 Middlefield R oad, Menlo Park, California 94025, USA 2 National Park Service, Mount R ainier National Park, Ashford, Washington 98304, USA

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Thomas H. Nylen. Spatial and Temporal Variations of Glaciers (1913-1994) on Mt. Rainier and the relation with dimate. Portland State University. 2004.

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R.W. McNabbet al. Using surface velocities to calculate ice thickness and bed topography: a case study at Columbia Glacier, Alaska, USA. Journal of Glaciology, Vol. 58, No. 212, 2012.

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