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# GIS-Based Methods for Determining Glacial Volume Change Over Time

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We employed various methods of calculating volumetric change from the same source data using ArcMap 10.6 to investigate differences and / or similarities between the results. These methods can be used to analyze gain and loss in glacial volume over time, which is the subject our analyses were based on. By comparing digital elevation models of the same area from different time periods, the difference in surface elevation multiplied by the difference in surface area of the feature being measured represents a change in volume. While it is possible to perform this calculation numerically, many of the values used would be estimates prone to a high margin of error. In contrast, assuming that the digital elevation models being used have a high degree of accuracy, GIS-based techniques are able to calculate this volumetric change much more precisely. In addition to our source DEMs, our analysis included 30m DEMs interpolated using the Spline, Inverse Distance Weighted, and Kriging interpolation methods as well as an additional set of 10m DEMs which were interpolated with the same methods, respectively, from the source 30m DEMs. All analyses were done using the “Cut Fill” tool in ArcMap. The spline interpolation method resulted in the smallest difference in volume, which was expected since spline is well-suited for areas with significant elevation variations. The Kriging method was the next smallest, with IDW resulting in the largest difference. Additionally, the 10m DEM analyses resulted in larger differences than the 30m DEMs. All numerical results of these analyses likely have a high margin of error due to the aggregation of error from the various conversions required to produce our historical source DEM.

# Glacier Change on Mt. Hood 1983-2017

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# Research Questions

- How does glacier volume change when using different interpolation methods?
- What effect does downscaling DEM resolution using interpolation have on volumetric calculations?

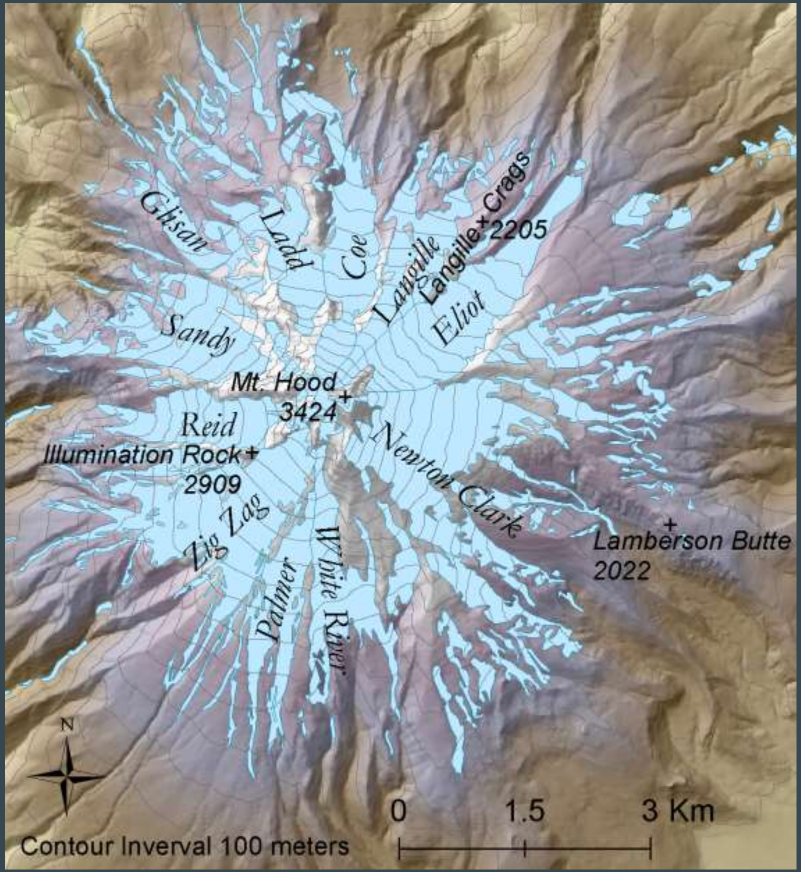
# Study Area

Mt. Hood was chosen as the study area due to:

- Availability of DEMs compared to other glaciated mountains

- Glacier change on Mt.  Hood is well researched

Many studies have been done on volumetric change on one specific glacier; our goal is to look at the entire glaciated region’s volume change.



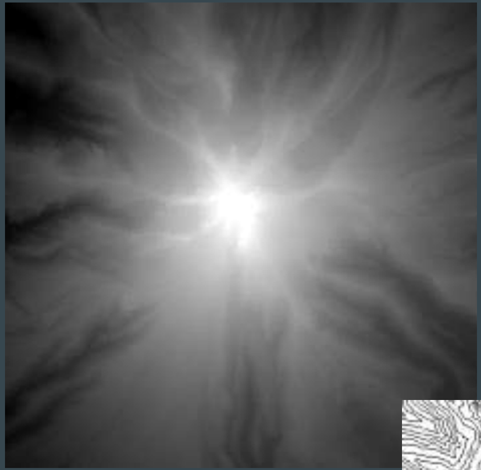
# Datasets

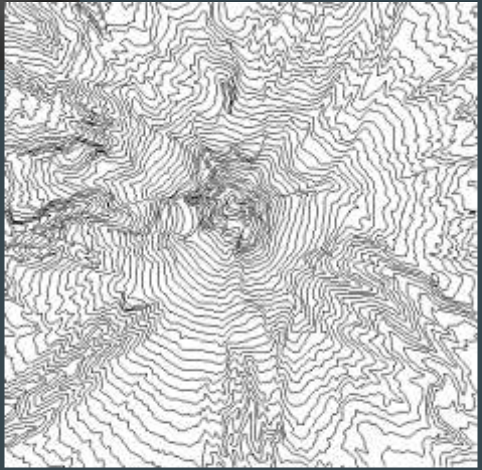
Collected

- 1983 50m Hypsographic DLG - Mt. Hood
- 2017 30m DEM - Mt. Hood
- GLIMS glacier outline feature class

Created

- 30m Linear DEM from 1983 DLG
- Interpolated 30m DEM 1983 (Kriging, Spline, IDW)
- Interpolated 10m DEM 1983/ 2017 (Kriging, Spline, IDW)

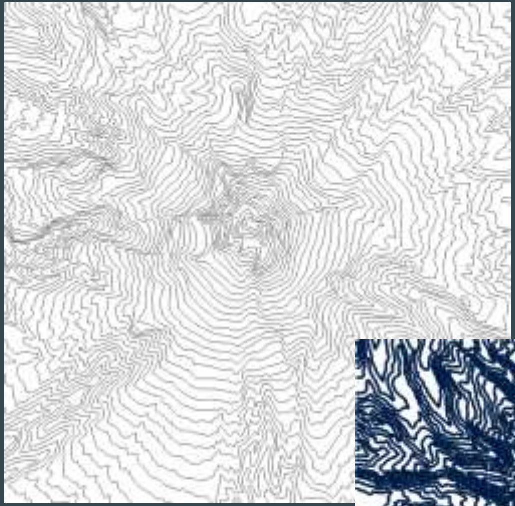


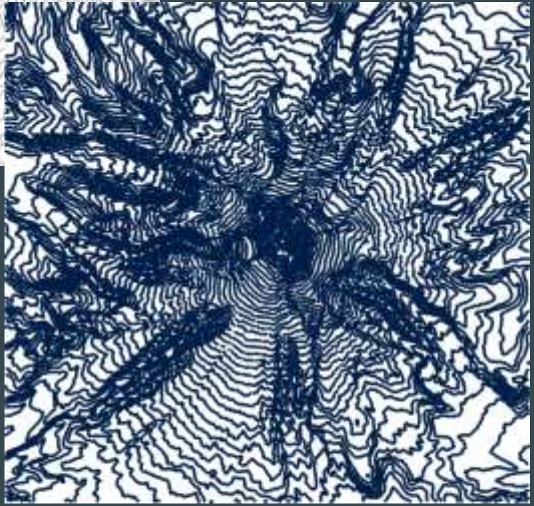


# DLG Process

For our 1983 data, we created a DEM from USGS hypsographic Digital Line Graph datasets of 50m digitized contour lines from 1983 topographic map.

- Using a freeware application, original DLGs were converted into tables and shapefiles
- Tables and shapefiles were joined into a single polyline feature class
- The polyline feature class was then converted into points using the “Generate Points along Lines” tool
- Resulting point feature class then converted into 30m DEM using the “Spline” tool





# Analysis

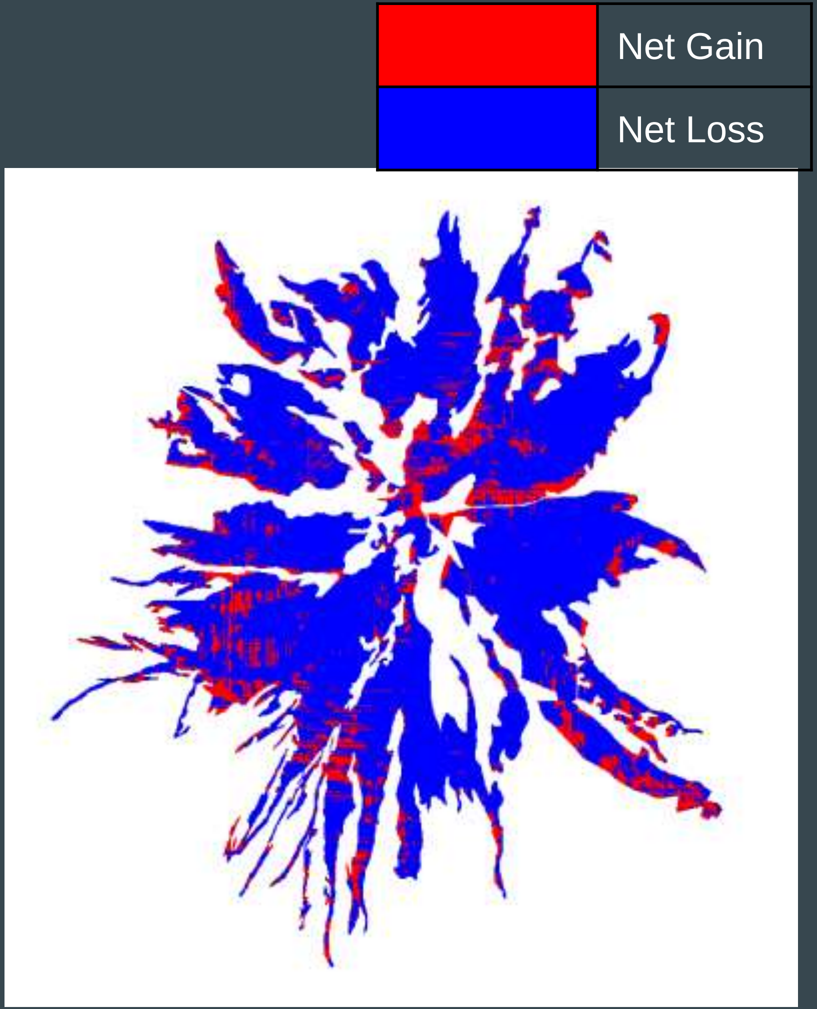
## Extract by Mask

- Spatial Analyst
- Extracts cells of a raster that correspond to areas defined by a mask
- Input = DEM and glacier outline
- Output = DEM of just the glaciers

# Analysis

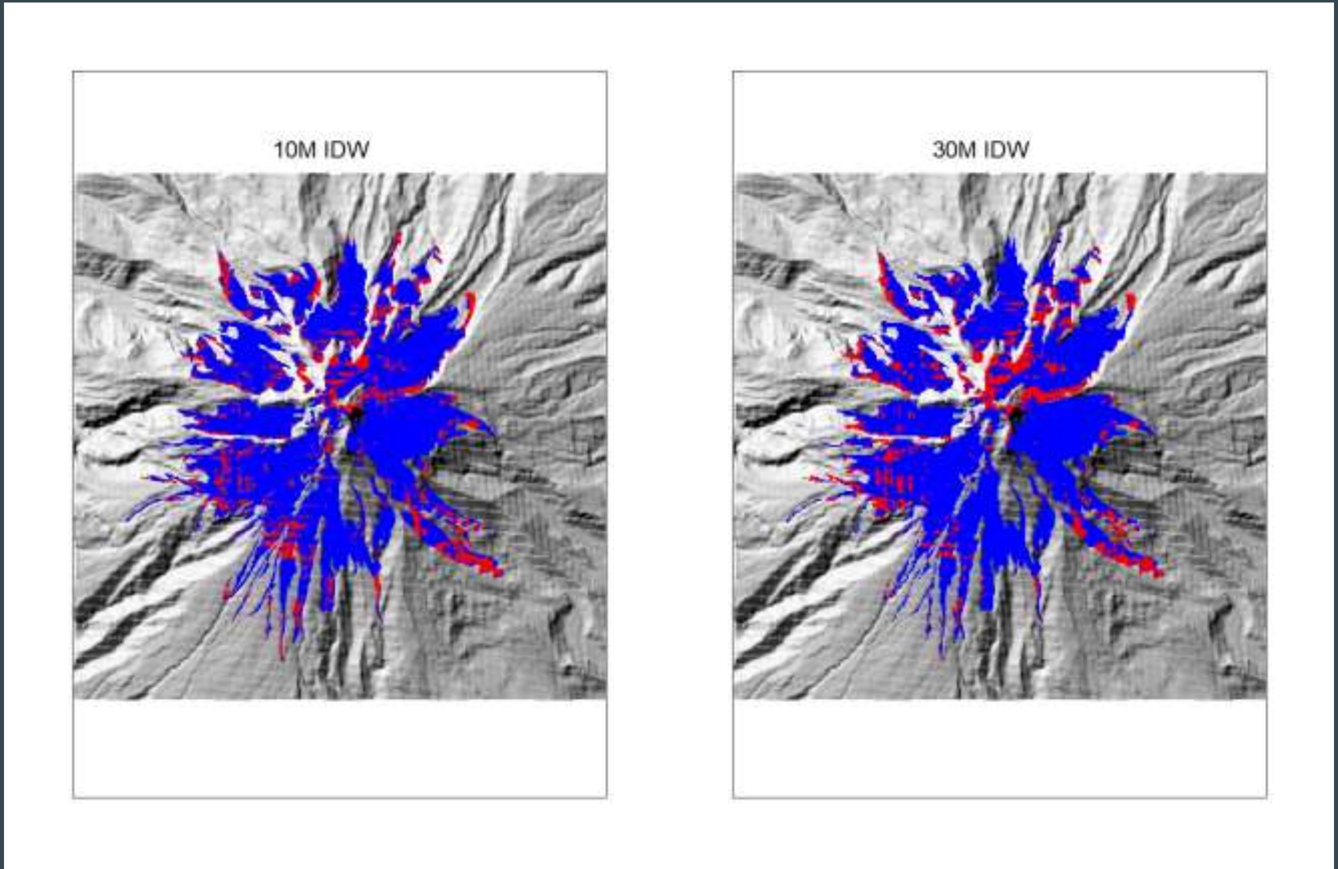
## Cut Fill

- Spatial Analyst
- Calculates areas and volumes of change
- Input = before 1983 DEM, after 2017 DEM
- Output = **positive** values represent areas of “cut” (volumetric **loss), negative** values represent areas of “fill” (volumetric **gain**)



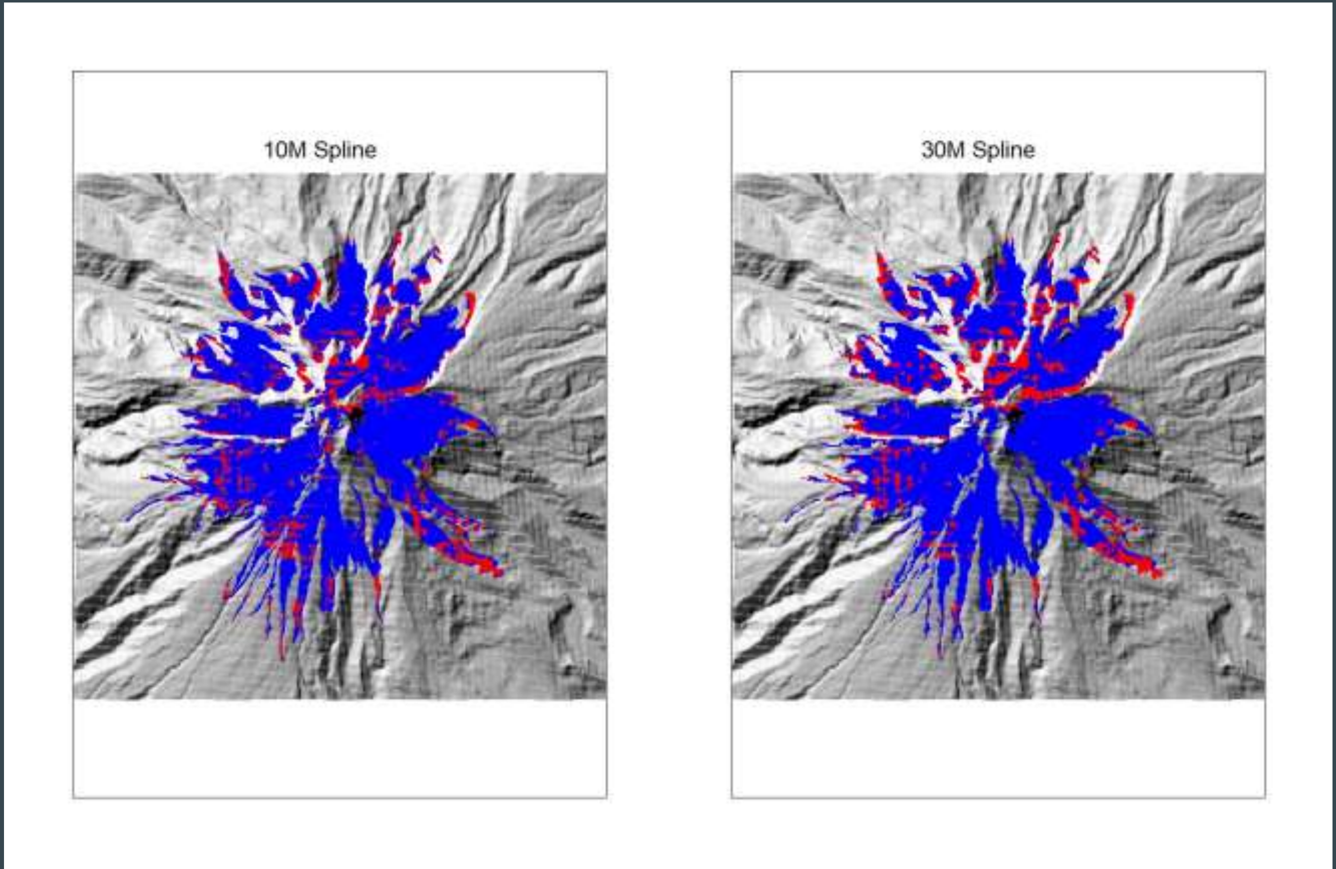
# Results

| | |
|---|---|
| | Net Gain |
| | Net Loss |



# Results

| | |
|---|---|
| | Net Gain |
| | Net Loss |



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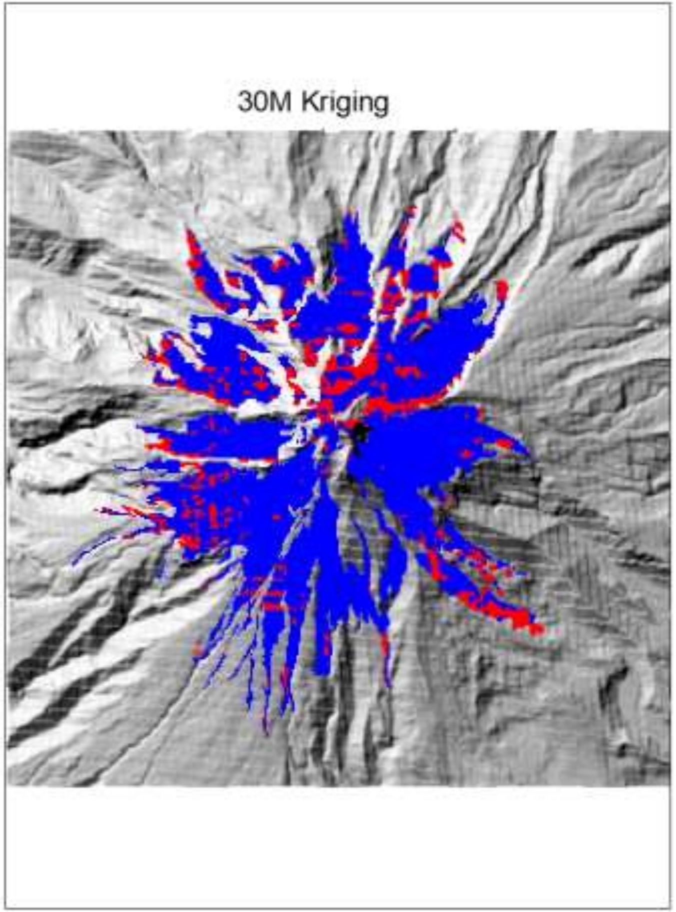


| | |
|---|---|
| (red) | Net Gain |
| (blue) | Net Loss |

# Results

| | 30M DEM Spline | 10M DEM Spline | 30M DEM IDW | 10M DEM IDW | 30M DEM Kriging |
|---|---|---|---|---|---|
| Estimated volumetric change $m^3$ (1983-2017) | 217,963,069.73 | 230,462,707.7 | 239,857,048.94 | 260,947,906.76 | 224,866,601.4 |
| | Change in Spline | 12,499,637.96 | Change in IDW | 21,090,857.82 | |

- DEM interpolations resulted in average volumetric loss of about 234 million $m^3$
- 10M DEMs had a higher volumetric loss than the 30M DEM
- Spline interpolation resulted in smallest change, IDW had largest change

# Results

Possible reasons for discrepancies

- Study Area
- Aggregation of error creating 1983 DEM
- Difference in source DEM resolutions
- Time of year of data acquisition

# Sources

- United States Geological Survey - National Elevation Dataset, DLG Archive
- Global Land Ice Measurements from Space (GLIMS) - World Glacier Inventory
- Dr. Bruce Ralston, University of Tennessee - DLG Conversion Software
- Dr. Andrew Fountain, Portland State University - Imagery and Advice
- Environmental Systems Research Institute (Esri) - Tutorials