Measuring Deflation of Debris-Covered areas vs pure Glacial Ice areas on the Eliot Glacier, Mt Hood, OR

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Digital Terrain Analysis

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Abstract: Measuring Deflation of Debris-Covered Ice vs Pure Glacial Ice on the Eliot Glacier, Mt Hood, OR

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Measuring glacier volume change, with estimated knowledge of ice base depth, begins with quantifying surficial deflation. Although current glacier volume estimates are measured throughout the world, there are certain drawbacks that call for more specialized measurement methods. One of the main flaws of worldwide glacial ice/snow surveys is that debris-covered glaciers are often misrepresented, resulting in underestimation of area and volume for those glaciers. Debris-covered glaciers have special properties that make them unique, such as melt rate suppression and meltwater discharge stability. Manipulating radar bands, creating snow/ice imagery like the GLIMS model, leave out the massive, continuous layers of supraglacial debris that blanket much of the ablation zones in alpine glaciers. As time goes on, glacier debris area is thought to increase as glacial erosion of steep mountain walls continues.

This project is based on the project my friends Alli and Nick produced last fall. They used the same technique of differencing DEM's using the Cut Fill tool (Spatial Analyst toolbox). However, the study extent for this is set to the extent of the Eliot Glacier, a debris-covered glacier on the NE flank of Mt Hood. I also sourced a 1996 DEM of North America instead of going through the tedious process of DLG to shapefile conversion (the freeware is no longer available). The 1996 DEM had larger pixels than the 2008 DEM, so I resampled it to equalize the pixel size. Then I used the Cut Fill to find the change in elevation between the two DEM's, which is the deflation rate. From there, the outline of the debris-covered portion of the glacier becomes the new extent. The deflation rate of the debris-covered portion subtracted from the total glacier extent is the deflation rate of the non-debris-covered area. The two values are compared.

In this project, I found the debris-covered ice deflation to be LOWER than the debris-free deflation. It contradicts with the fact that most of the debris-covered area is within the ablation zone. However, because of the insulating properties of the debris, it may insulate the underlying ice enough to inhibit deflation. Resolution differences in the DEMs as well as what part of the year the elevation data was acquired can also significantly impact the results.

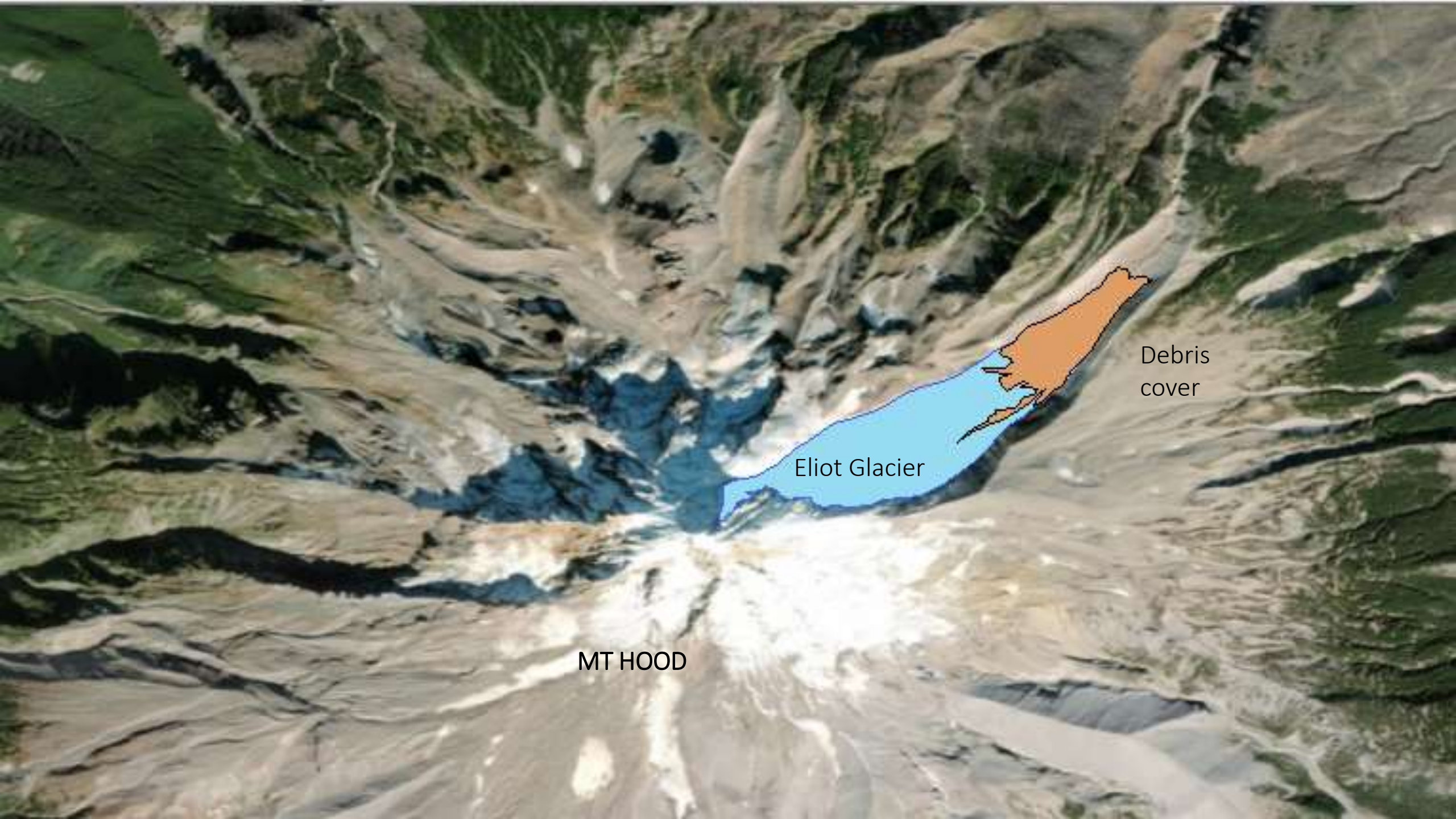
Debris-Covered Glaciers Crash Course

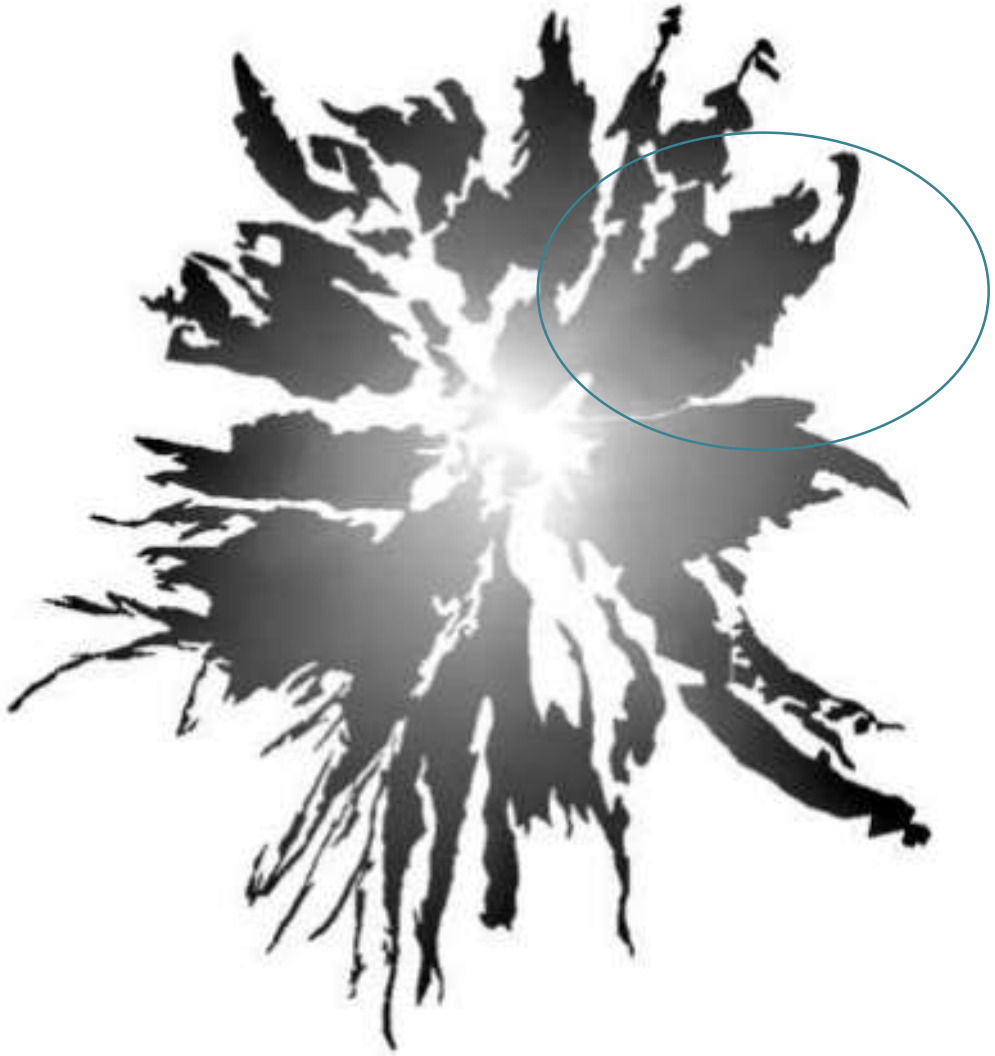
Debris-covered glaciers: Terminus and much of the ablation zone (annual net mass loss region) covered in rocky debris.

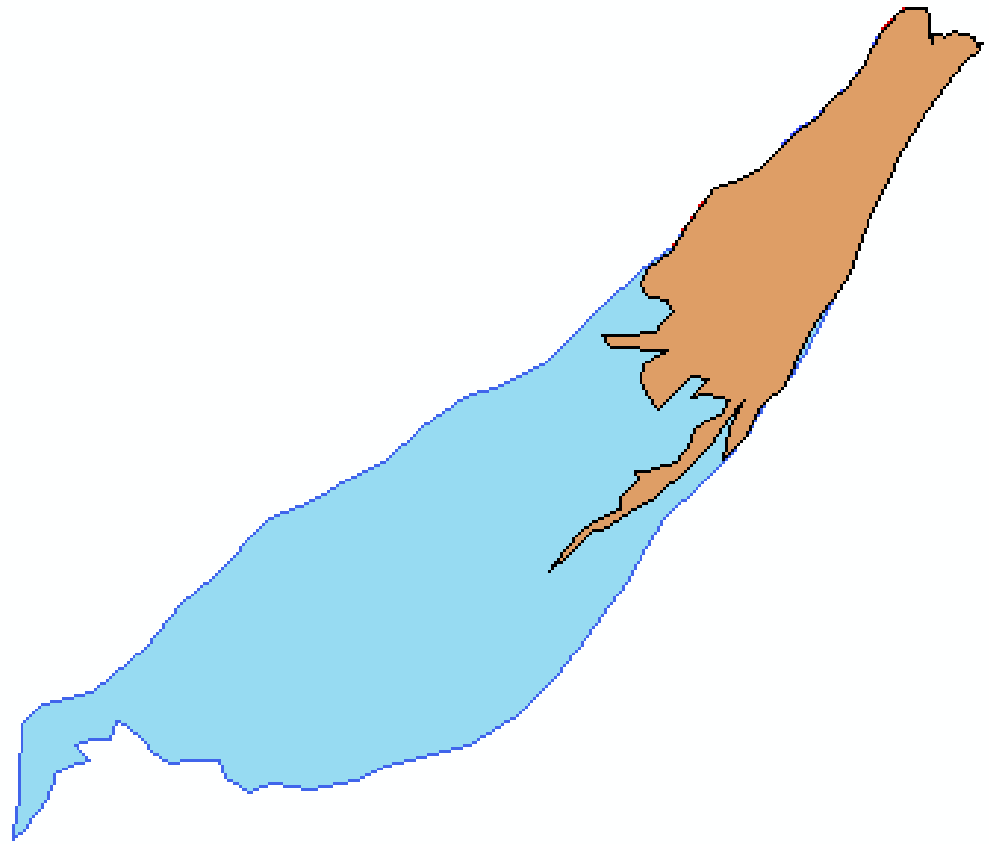
Thick, continuous debris layers insulate ice and reduce melt rates and produces less 'flashy' meltwater runoff patterns. Chaotic inner hydrological structure reduces overall meltwater discharge.

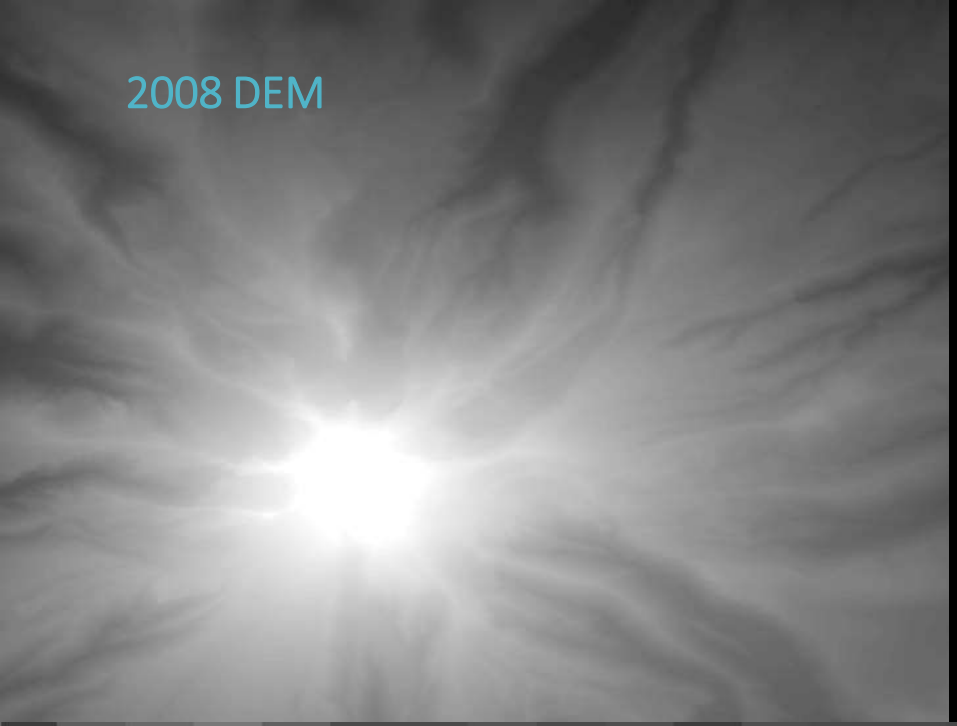
Snow/Ice models tend to leave debris-covered ice behind, resulting in severely underestimated area/volume values.

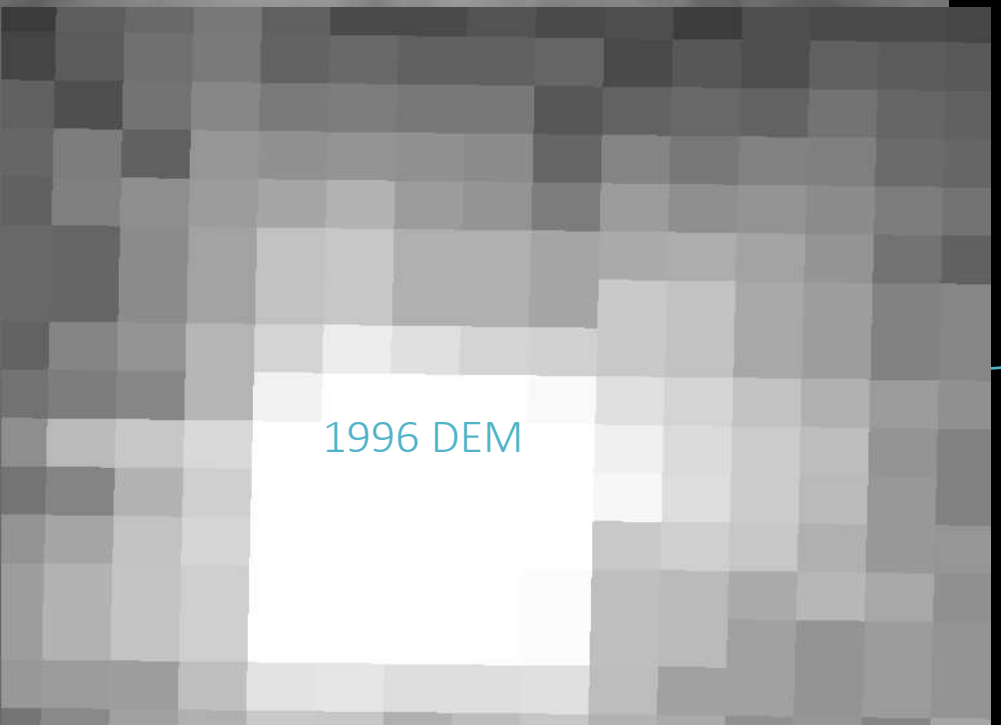
Debris thickness, debris extent/area, debris-covered ice ratio difficult to measure


Debris
cover
Eliot Glacier
MT HOOD

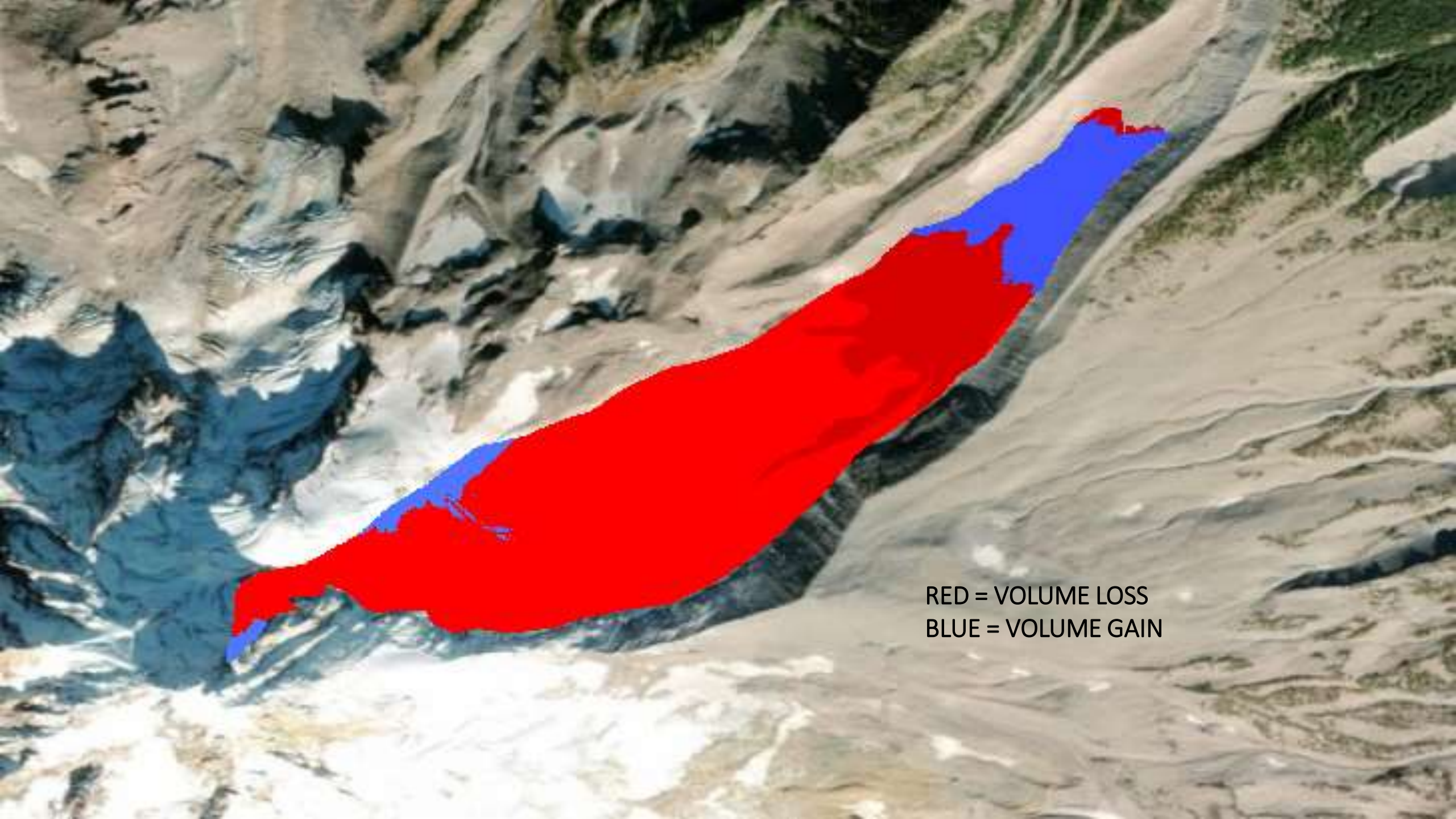





2008 DEM


1996 DEM


1996 DEM resampled
(Bilinear)


RED = VOLUME LOSS
BLUE = VOLUME GAIN

ELIOT GLACIER	Area	Deflation (m^3)	Deflation per sq m
Total	1560767.74	66720328.90	42.748
Debris-covered portion	423013.74	8143268.32	19.251
Clean ice	1137754.00	58577060.58	51.485

Eliot Glacier Cut Fill Results

Discussion

Resampled 1996 DEM and 2008 DEM different resolutions

Date/season elevation data was collected (snow-free measurements time sensitive)

Debris-Covered Area: Insulated ice beneath debris reducing deflation?

Sources

1996 DEM: USGS EROS Archive - Digital Elevation - Global 30 Arc-Second Elevation (GTOPO30)

2008 DEM: USGS Earth Explorer

Mt Hood Debris-Covered Glacier Inventory, 2017 extents, digitized by Cole Carr

Mt Hood snow/ice extent figure: GLIMS World Glacier Inventory