A sensitivity analysis of scale and sampling techniques on volumetric change on Mount St. Helens

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Abstract
Mount St. Helens (MSH) underwent significant change during the 1980 eruption, thus altering the landscapes immediately surrounding the volcano. Calculating volumetric change (of both MSH and other areas) is a common technique; often though, little care is taken when deciding on resampling and interpolation techniques when comparing GIS layers of different resolutions. This study aims to determine 1) the effect of resampling and interpolation techniques and 2) effects of scale on volumetric calculations. A 30m pre-eruption DEM of MSH was interpolated down to 15m, 6m, and 3m using natural neighbor, spline, inverse distance weighting, and kriging. Then, a 3m LiDAR-derived DEM was resampled up to 6m, 15m, and 30m using nearest neighbor, bilinear, and cubic generalizations. Within each resolution group, all possible non-erroneous combinations were used to calculate the volumetric change between pre and post-eruption MSH. Results showed that upscaling had little to no effect, while downscaling had marginal effects on volume change. Splining was the best interpolation technique for estimating volumetric change while inverse distance weighting and kriging were the worst. Further, differences in scale proved to have the most variance within volume estimates. Both 3m and 30m had no variation, while 6m and 15m showed large variance in volumes, most likely due to two separate techniques being used on these values. This study shows that downscaling contains a much higher likelihood of erroneous data than upscaling. Also, the smallest or largest scale possible should be selected as intermediate scales contain much wider data variation.

Keywords: Mount St. Helens, interpolation, GIS, change detection, scale, spatial techniques

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Goals

- How do different interpolation techniques affect volumetric change calculations?
- How do differences in spatial resolution affect volumetric change calculations?
- Used Mount St. Helens as a study site due to the large change in volume.

USGS

Background

- Recent history
  - 1479-1750: Kalama Eruptive Period
    - Frequent eruptions and lahars
  - 1980: Famous Eruption
    - Large removal of northern mountainside
    - Large lahars on all aspects
  - 1996: Large flooding events
    - Further incised lahar channel
  - 1980's – present: regrowth within caldera

Yamaguchi, 1995

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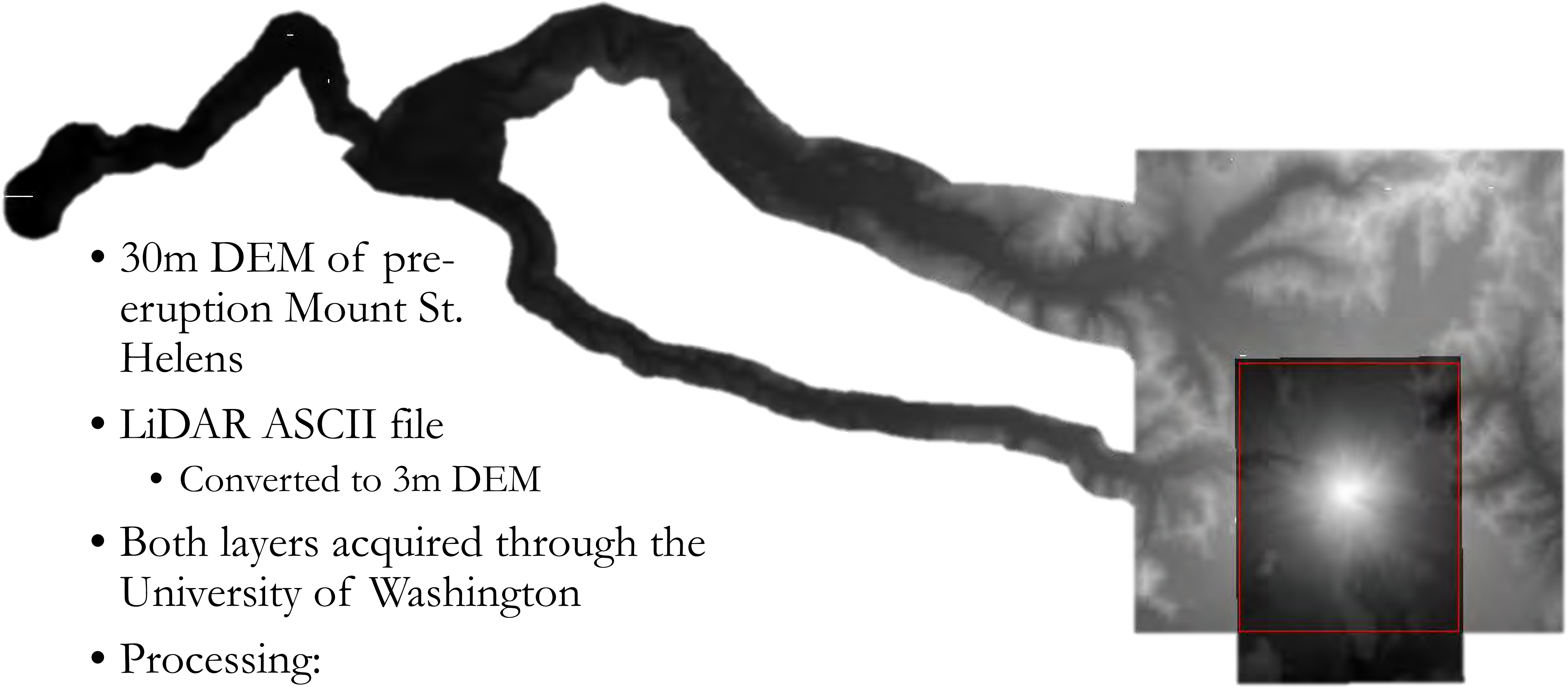
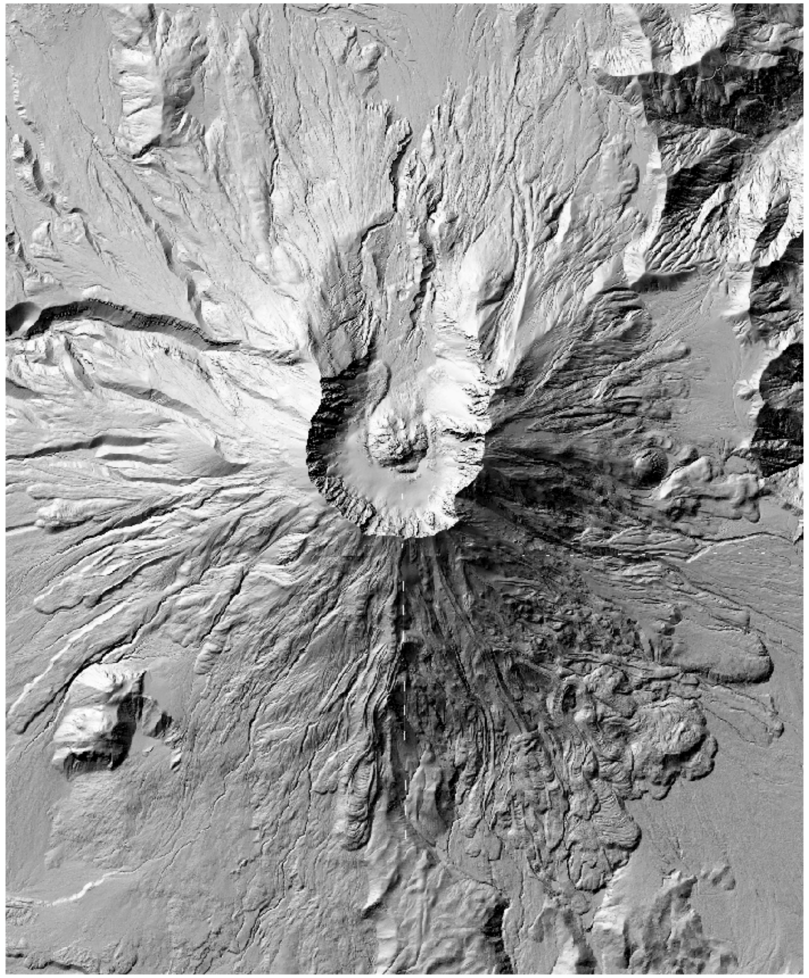
Data Processing



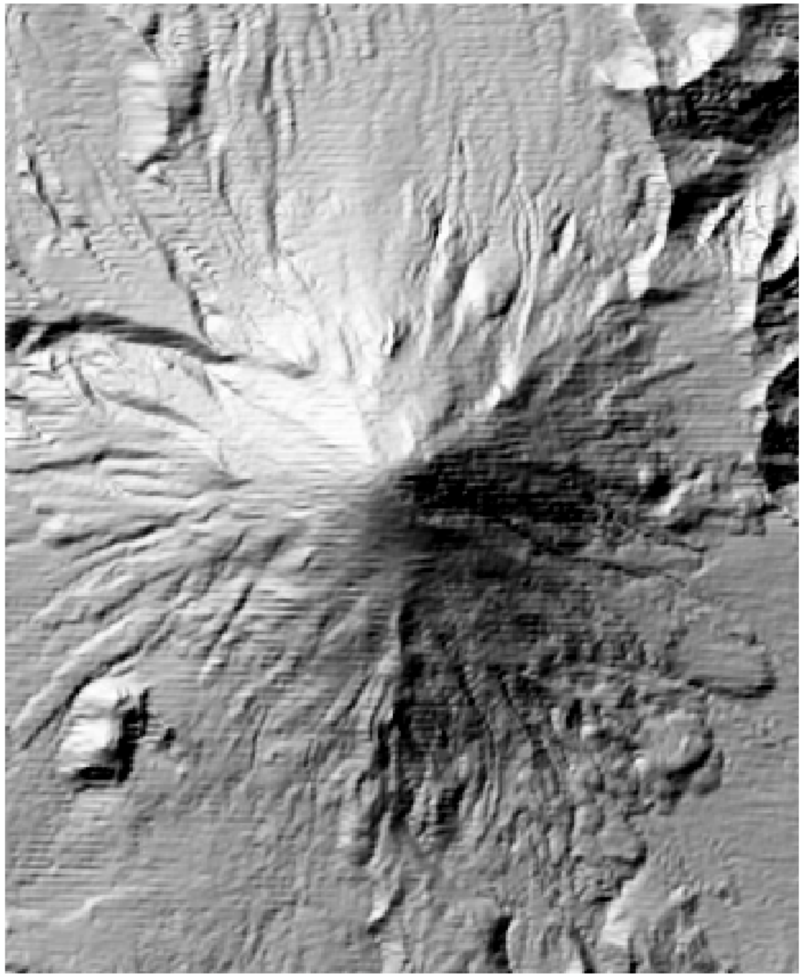
- 30m DEM of pre-eruption Mount St. Helens
- LiDAR ASCII file
  - Converted to 3m DEM
- Both layers acquired through the University of Washington
- Processing:
  - Layers were reprojected, aligned, and clipped to a new study area

Data Manipulation…

- Resampled 3m LiDAR layer up to 6m, 15m, and 30m
  - Used Nearest Neighbor, Bilinear, and Cubic
- Interpolated 30m pre-eruption DEM down to 15m, 6m, and 3m.
  - Used Natural Neighbor, Spline, Inverse Distance Weighting, and Kriging.
- QA/QC via visual inspection of hill shade layers
  - Removed erroneous data layers

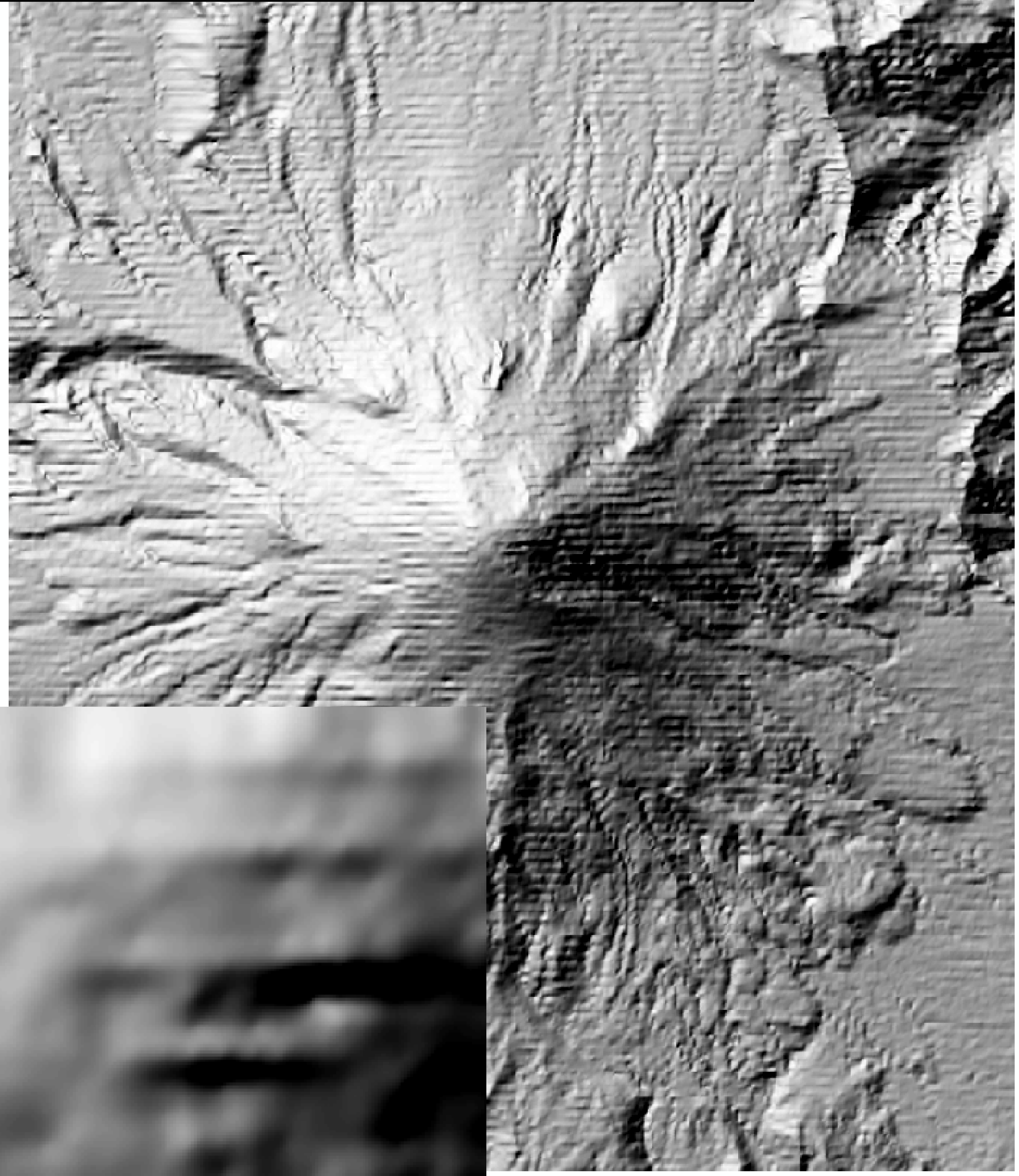


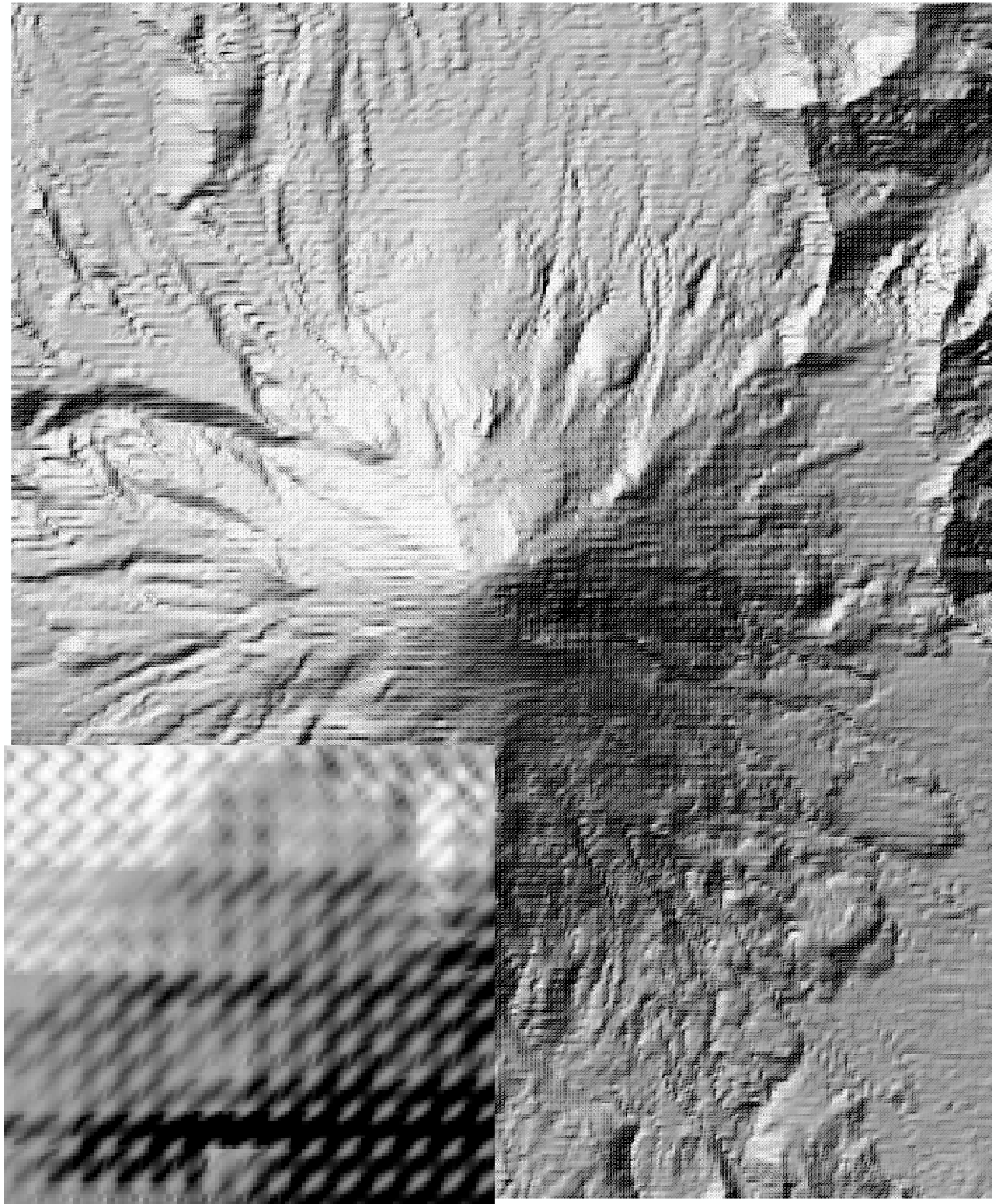
3m LiDAR Image



30m DEM

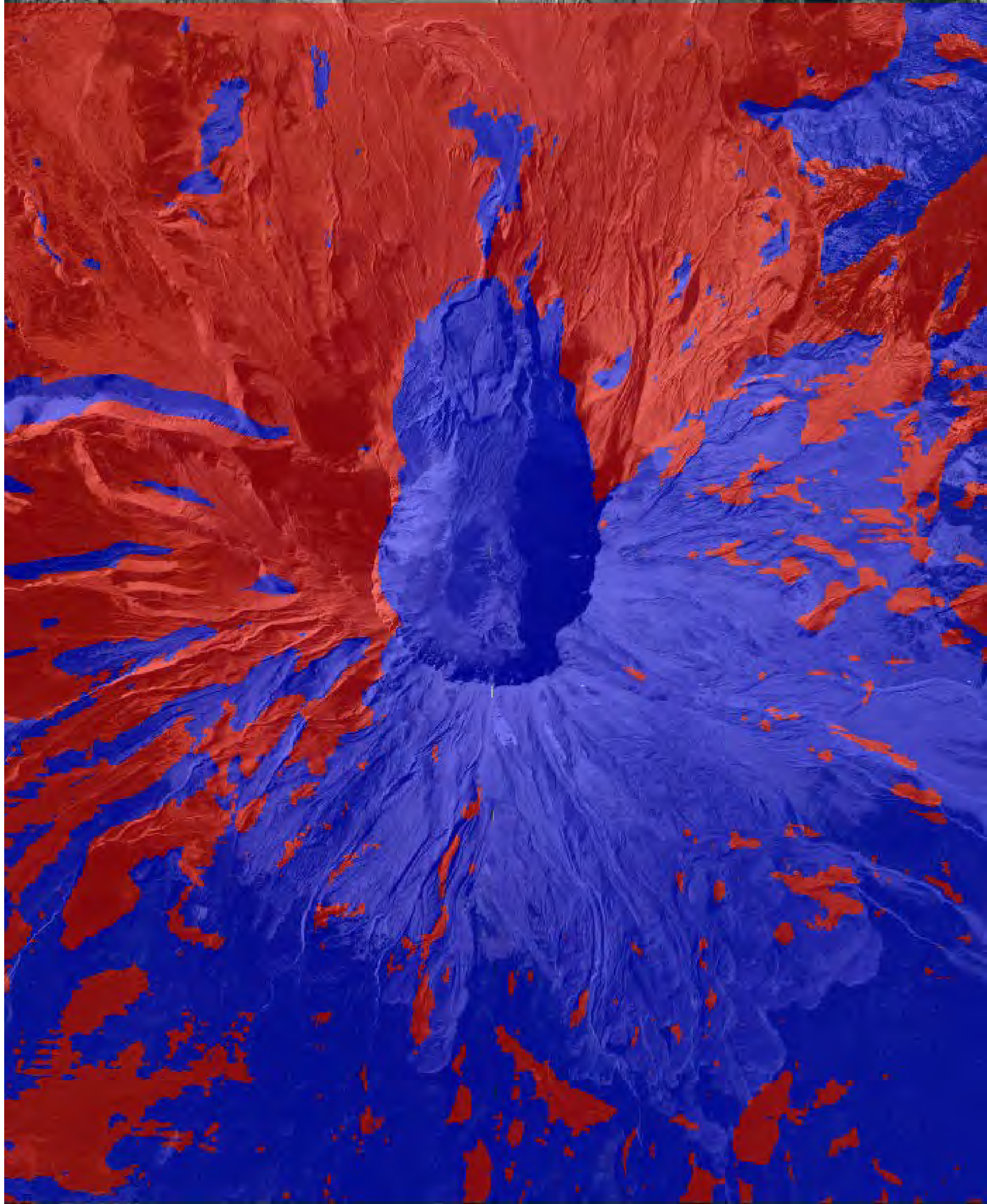
3m DEM via Spline (Left) and IDW (right)





Calculating Volume

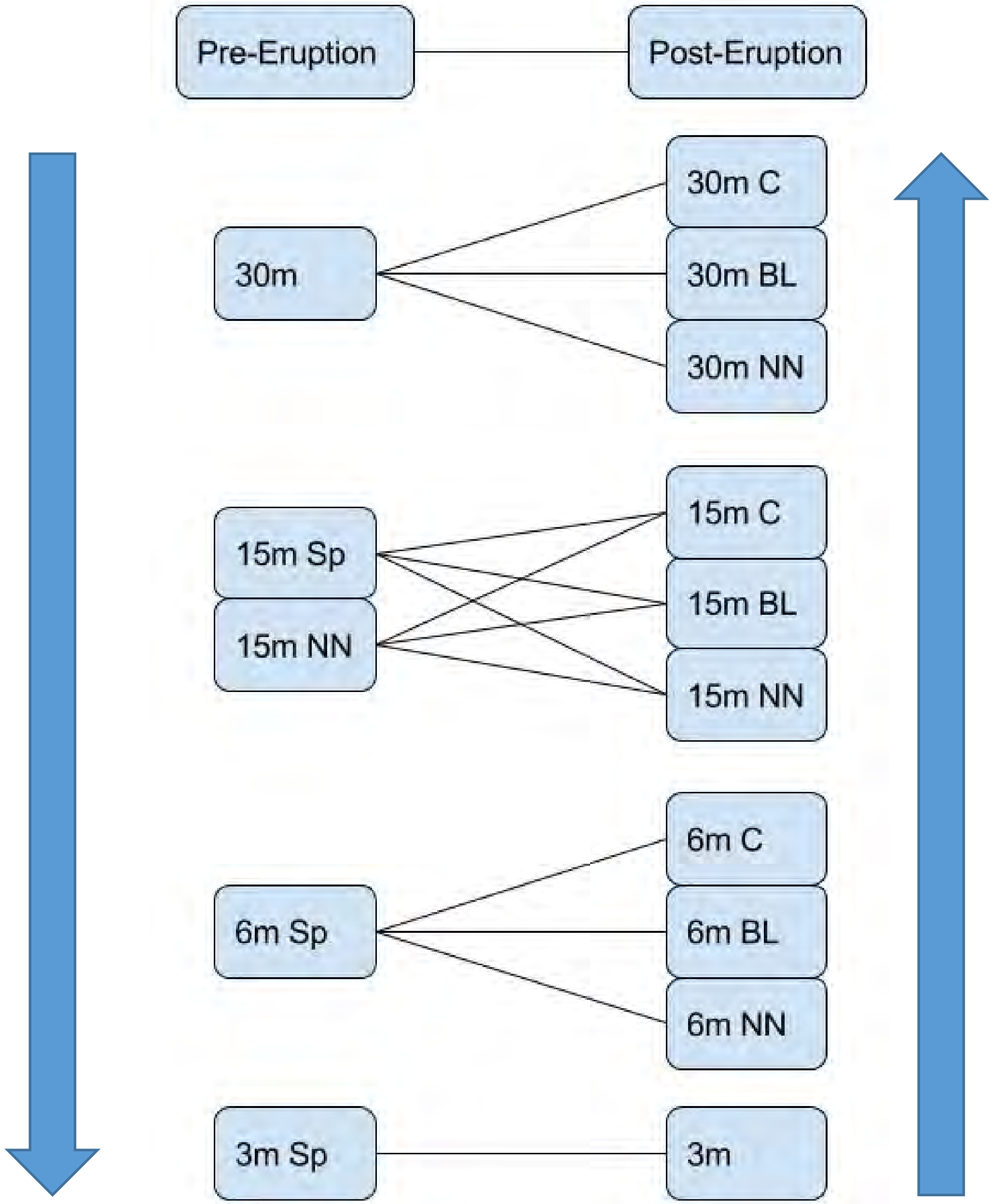
- Used cut fill tool to calculate volumetric change between all combinations of all layers
  - $\Delta V = pixel\ (x * y) * \Delta z(DEM_{new} - DEM_{old})$



Data: ESRI, NOAA, USGS

The effect of techniques

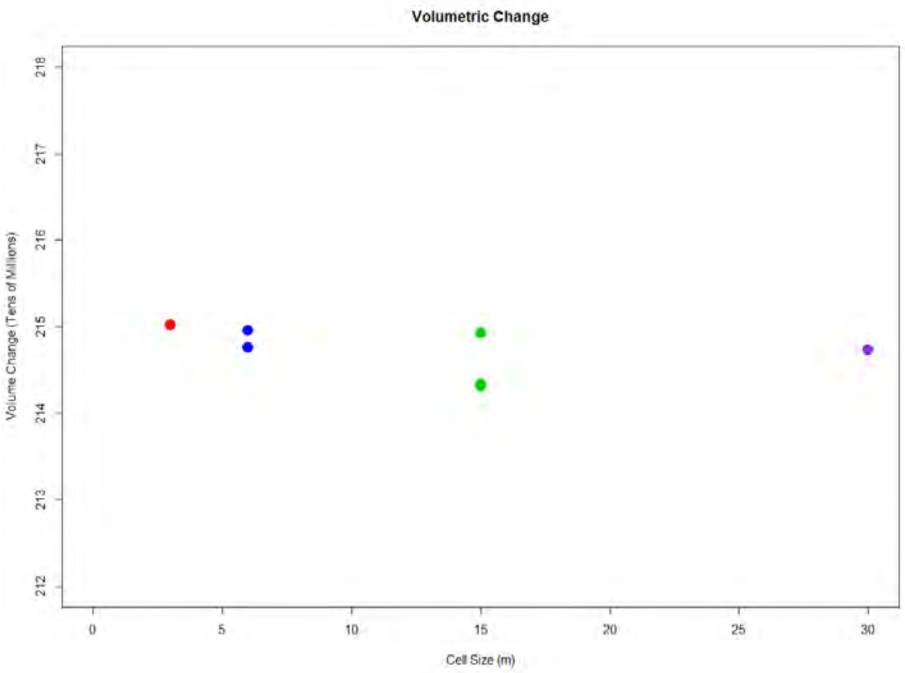
- The effect of techniques
  - IDW and Kriging were removed completely
  - Splining was most effective interpolation technique
  - Natural neighbor was removed after 15m
  - Little to no difference in resampling techniques
  - The downscaling method is more important than upscaling

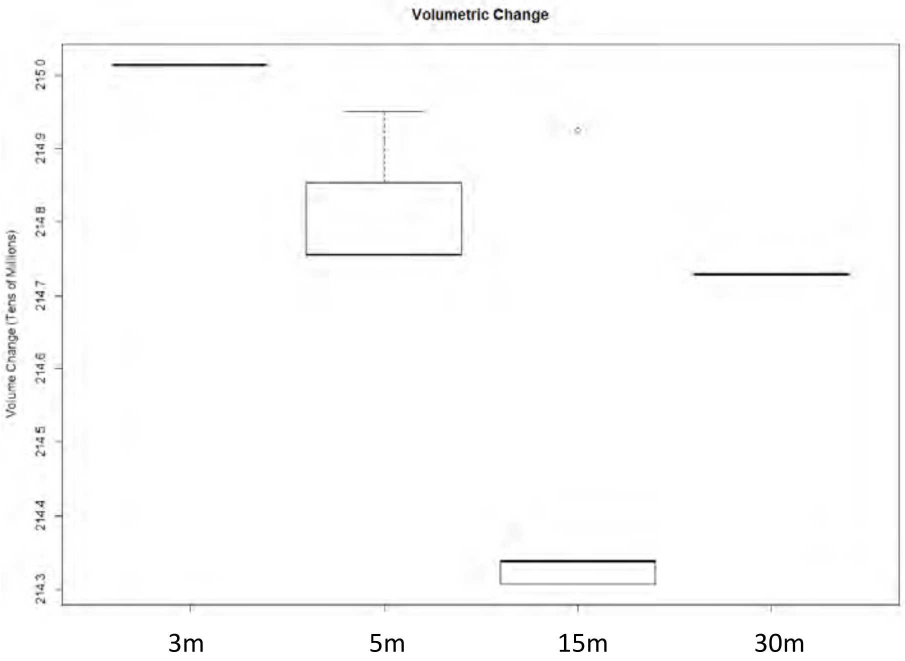


The effect of scaling

- Sample size to small to run most statistics
- The effect of scale
  - 3m comparisons showed largest change, 15m showed smallest
  - 6m & 15m (two forms of data manipulation) showed the greatest variance, while 3m & 30m showed little to no variance.
  - Variance differed more by scale than by resample/interpolation techniques

Cell Size (m)	Number	Mean Change	Change Variance
3	1	2,150,135,025	0
6	3	2,148,203,551	1,951,932
15	6	2,143,229,586	301,948
30	3	2,147,940,137	1,973,658
Total	13	2,145,995,662	7,056,413





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