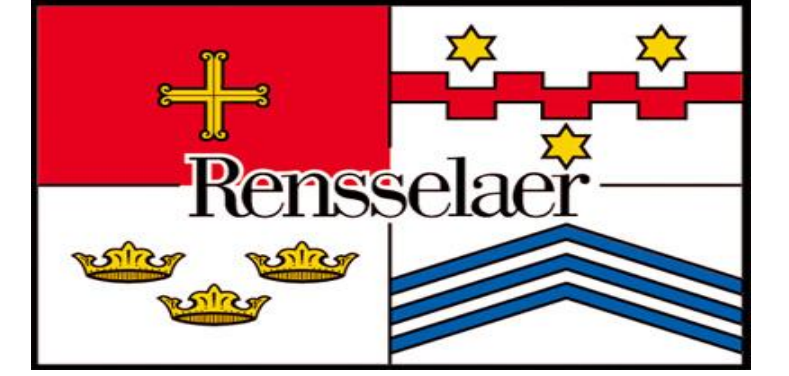


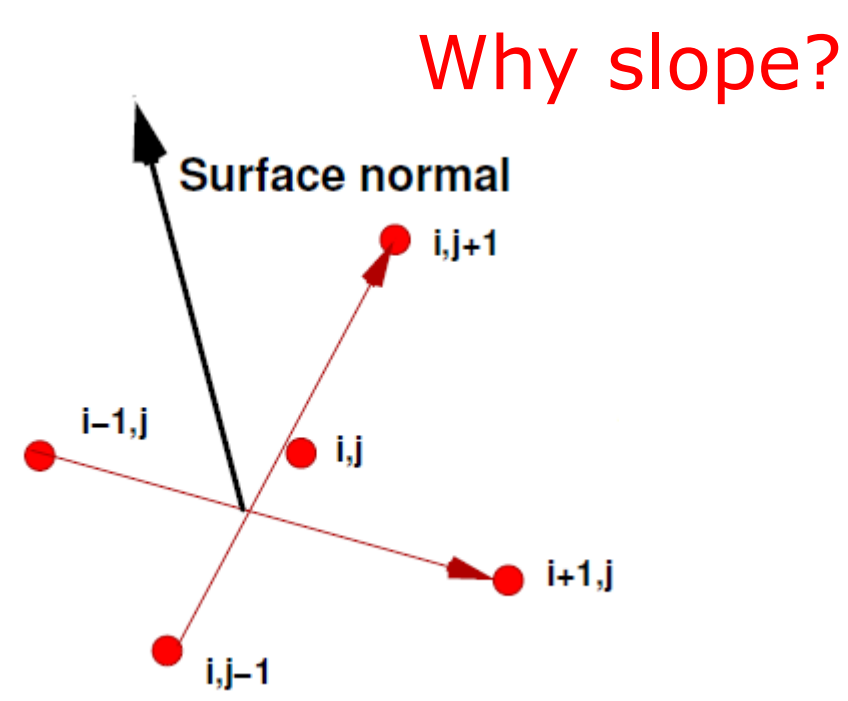
# Slope Preserving Lossy Terrain Compression

Zhongyi Xie, W. Randolph Franklin, Daniel Tracy  
Rensselaer Polytechnic Institute, Troy NY USA



## The Problem

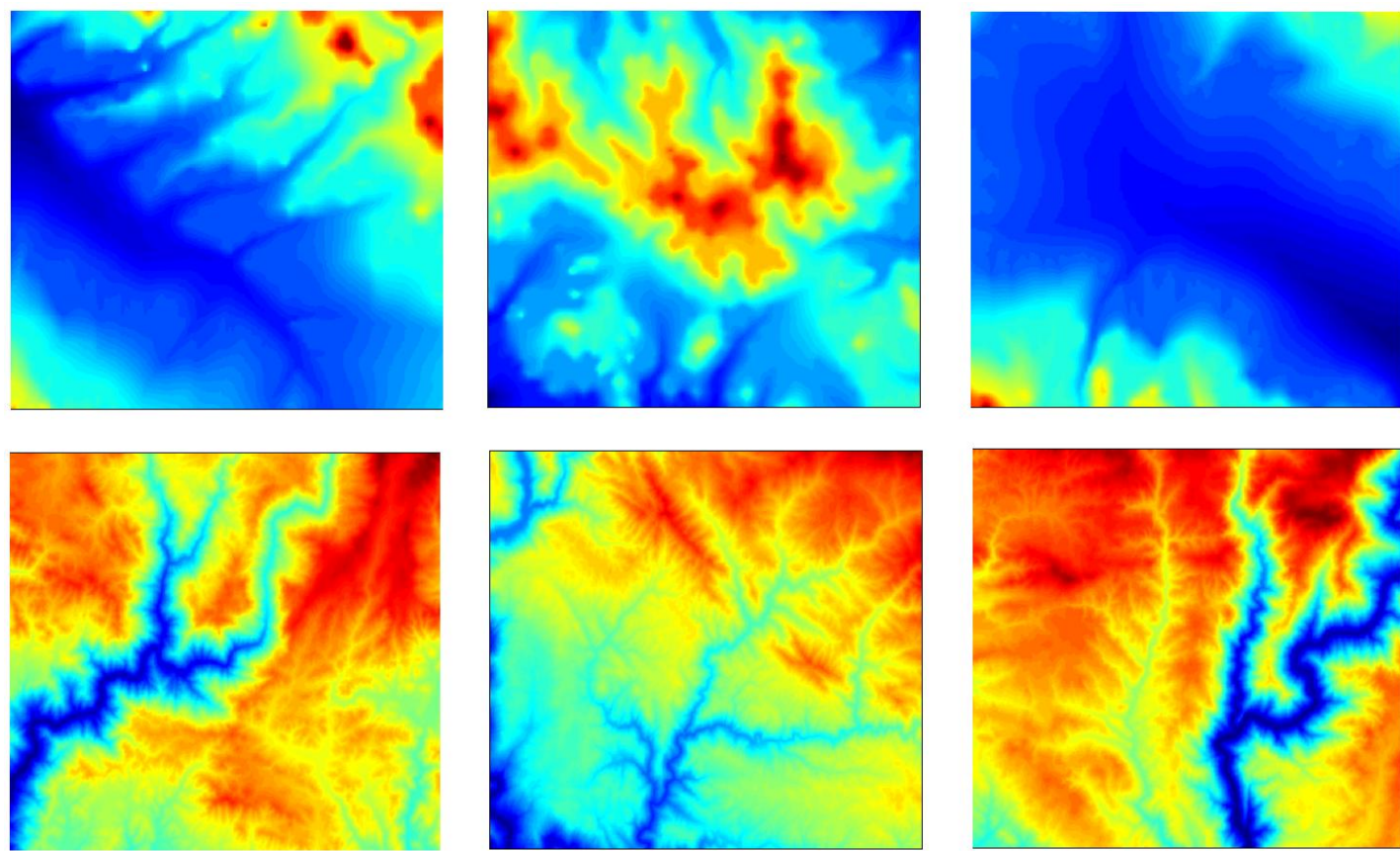
Lossy terrain compression, with the focus on preserving slope accuracy



## Motivations

- Slope accuracy is important for many applications:
  - Erosion, visibility, recognition, hydrology, mobility
- Being the derivative of terrain, slope accuracy could be compromised during the lossy compression of the terrain
- It is too costly to store slope explicitly
- Current methods often:
  - Purely treat the terrain maps as images,
  - Do not handle slope very well
  - Produce artifacts (e.g., abrupt slopes, acquisition footprint),
  - Show details that aren't justified.

## Test Data



- 400 X 400 level-II DTED DEMs , 320KB original size
- Elevation range: 500 -953 m.
- Slope range: 42°-60°
- 30 meters post spacing

## ODETLAP

- “Overdetermined Laplacian PDE”
- Inspired by, but mathematically quite different from, a Laplacian.
- Solution: time and space intensive, utilizes recent numerical computation science.
- Unique properties:
  - Infers mountain tops
  - Creates continuous slopes across contours.
  - Accurately models surfaces from a small set of points.

- $h_{i,j}$  – known data point (for some (i,j))
- $z_{i,j}$  – computed depth (for all (i,j))
- Create an overdetermined sparse linear system:
  - For known points, an “exact” equation:

$$z_{i,j} = h_{i,j}$$

- For all nonborder points, an “averaging” equation:

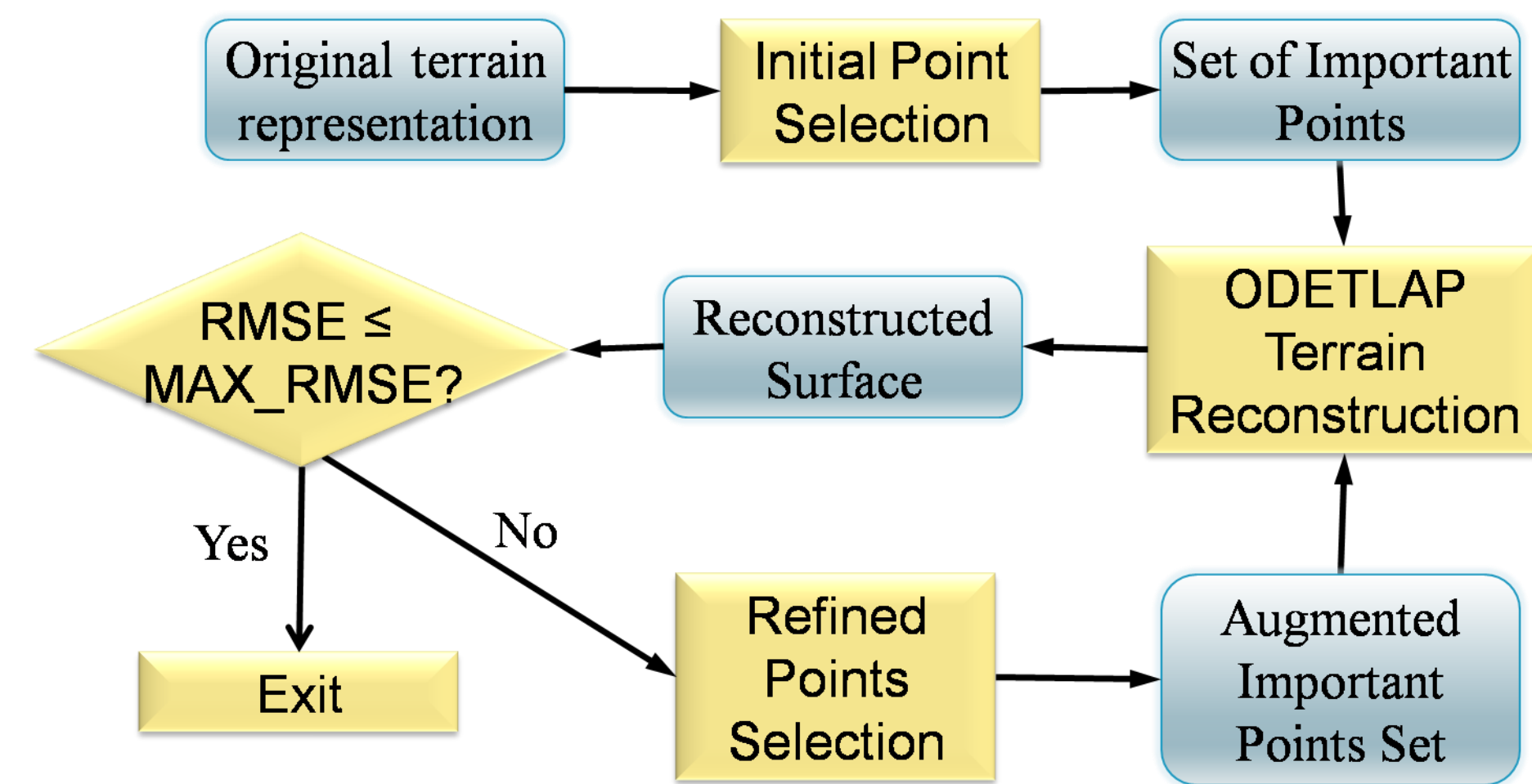
$$R(z_{i,j} = z_{i-1,j} + z_{i+1,j} + z_{i,j-1} + z_{i,j+1})$$

- For additional slope accuracy, two slope equations:

$$RS(z_{i+1,j} - z_{i-1,j} = h_{i+1,j} - h_{i-1,j})$$

$$RS(z_{i,j+1} - z_{i,j-1} = h_{i,j+1} - h_{i,j-1})$$

- $R$  trades off smoothness vs accuracy, pixel by pixel.
- Advantages:** conceptually (though not implementationally) very simple, approximates, not interpolates, known points.



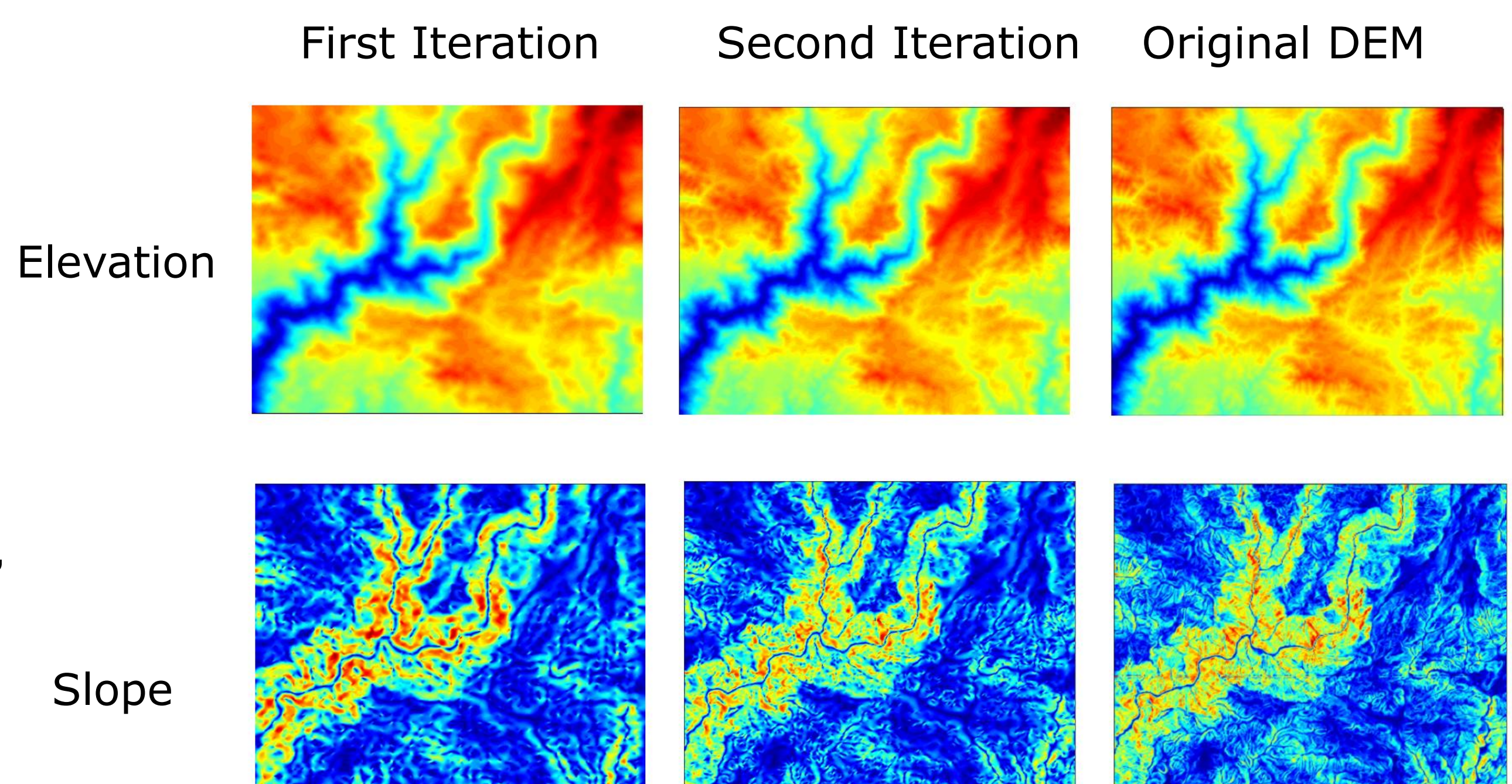
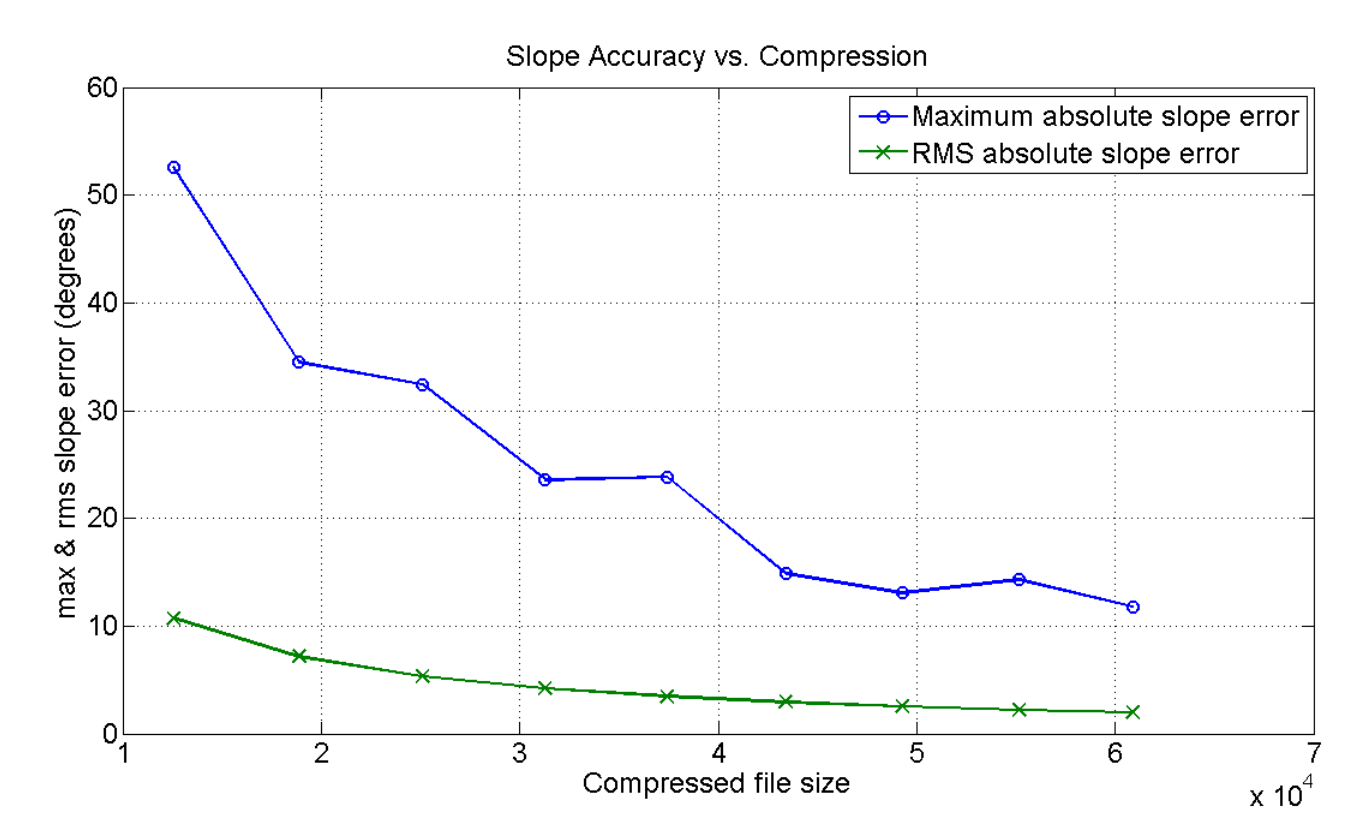
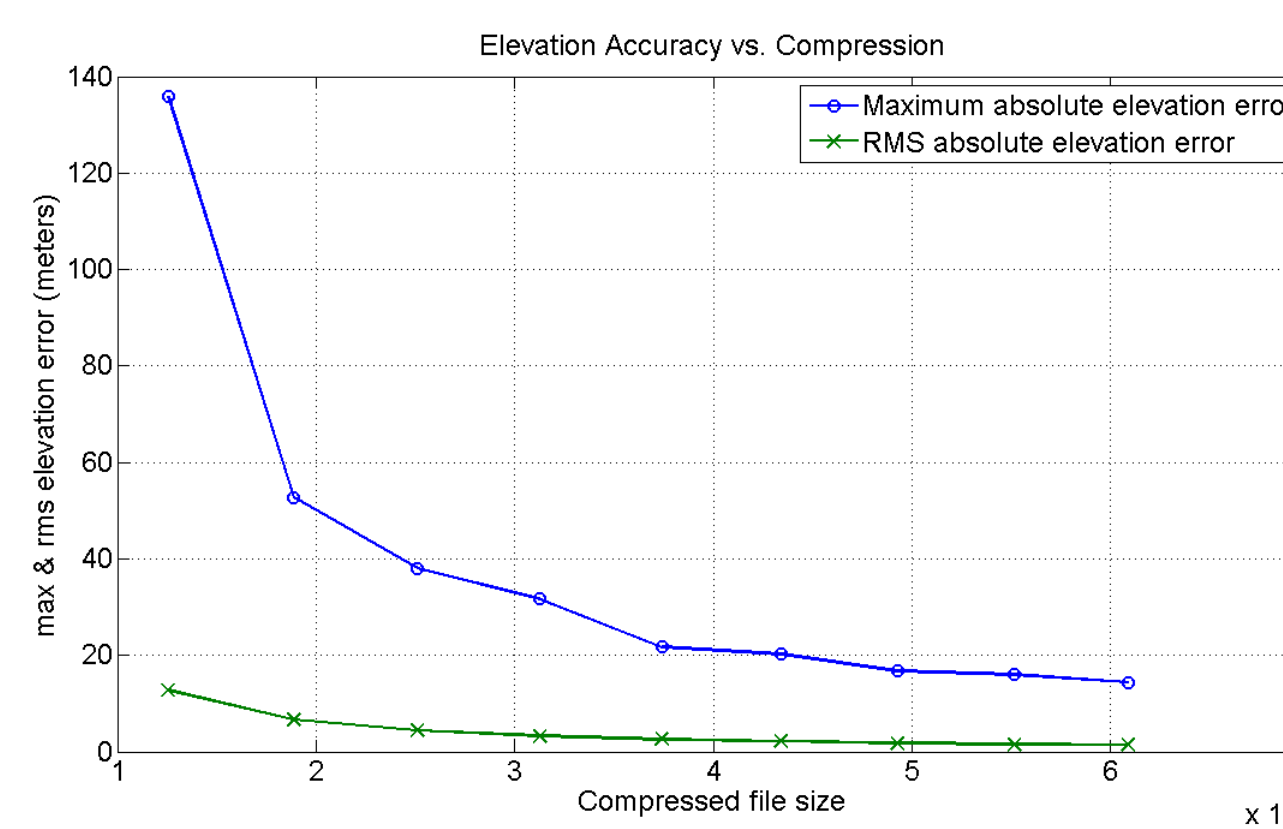
## ODETLAP Compression Algorithm

- Start with a sparse regular grid, save the grid spacing and elevations
- Use ODETLAP to obtain an initial reconstruction
- Find the points with greatest errors (elevation/slope) and include them into the point set S
- Use ODETLAP on the updated set S to solve for a finer approximation
- Return when desired accuracy is obtained or Maximum number of iteration is reached

## Encoding Point Set S

- The ODETLAP algorithm produces a set of points (x,y,z)
- Treat (x,y) pairs as bitmap, and compress (z) separately
- (x,y) bitmap:
  - When number of points < 8000, use Run Length Encoding
  - Otherwise, use png to encode the bitmap (we compared jj2k, png, tif, etc and png offers the best compression ratio)
- (z) stream
  - Scanline + linear prediction
  - Geometry algorithm: Minimum Spanning Tree
    - Closest ancestor
    - Ancestor average
    - Plane fitting
    - Division (lossy)

## Results



Reconstructed terrain and slope at different compression levels.