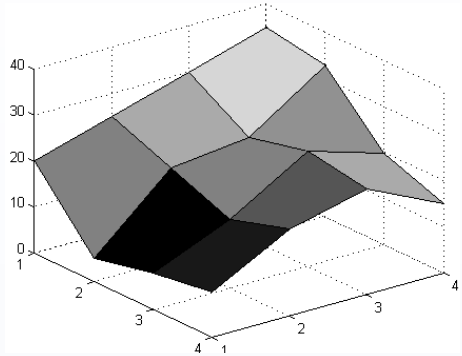
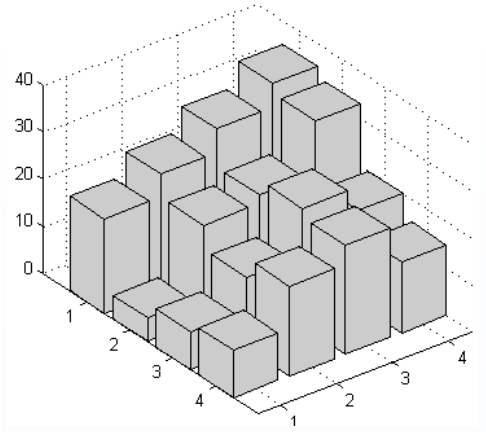
# EGM702 – Photogrammetry and Advanced Image Analysis

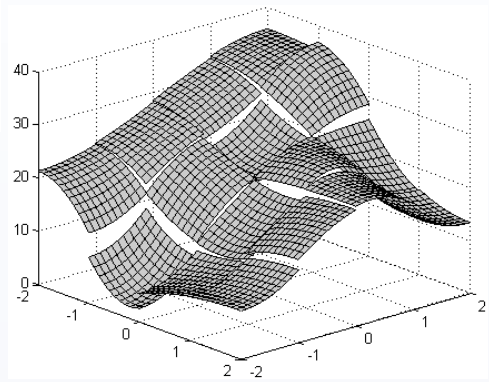
## Week 2, Part 2: Topographic Analysis

# Topographic Attributes

- Parameters that we derive from the surface (e.g., slope, aspect, curvature)
- DEM represents a (presumably) continuous surface $z = f(x,y)$
- In practice, use discrete surface
- Mathematical derivatives:
  - Slope: $f'$ (first derivative)
  - Curvature: $f''$ (second derivative)







# Taking derivatives

- Normally use 3x3 window around each pixel
- Derivative approximated for center of window ($Z_5$)
- Different algorithms use different approximations

| | | | |
|---|---|---|---|
| | $Z_1$ | $Z_2$ | $Z_3$ |
| | $Z_4$ | $Z_5$ | $Z_6$ |
| $L$ | $Z_7$ | $Z_8$ | $Z_9$ |

# Slope (gradient)

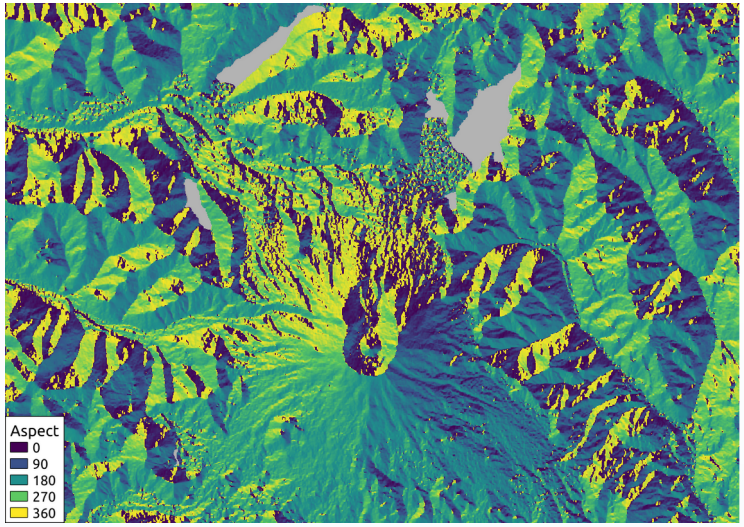
- Rate of change of elevation
- Can approximate in many ways
- "D8 Method": $s = \max_i \frac{Z_5 - Z_i}{L\,\phi(i)}, \quad \phi(i) = 1, \sqrt{2}$
  - Steepest downhill slope to neighboring pixel
  - Normally slightly lower values
- Using finite difference (ex.):

$$s = \sqrt{Z_x^2 + Z_y^2} \qquad Z_x = \frac{(Z_3 + 2Z_6 + Z_9) - (Z_1 + 2Z_4 + Z_7)}{8L} \qquad Z_y = \frac{(Z_7 + 2Z_8 + Z_9) - (Z_1 + 2Z_2 + Z_3)}{8L}$$

| | | | |
|---|---|---|---|
| | $Z_1$ | $Z_2$ | $Z_3$ |
| | $Z_4$ | $Z_5$ | $Z_6$ |
| $L$ | $Z_7$ | $Z_8$ | $Z_9$ |

# Aspect

- Aspect: the slope orientation
- i.e., the direction that the slope faces
- Useful for modelling:
  - Hydrology
  - Solar illumination

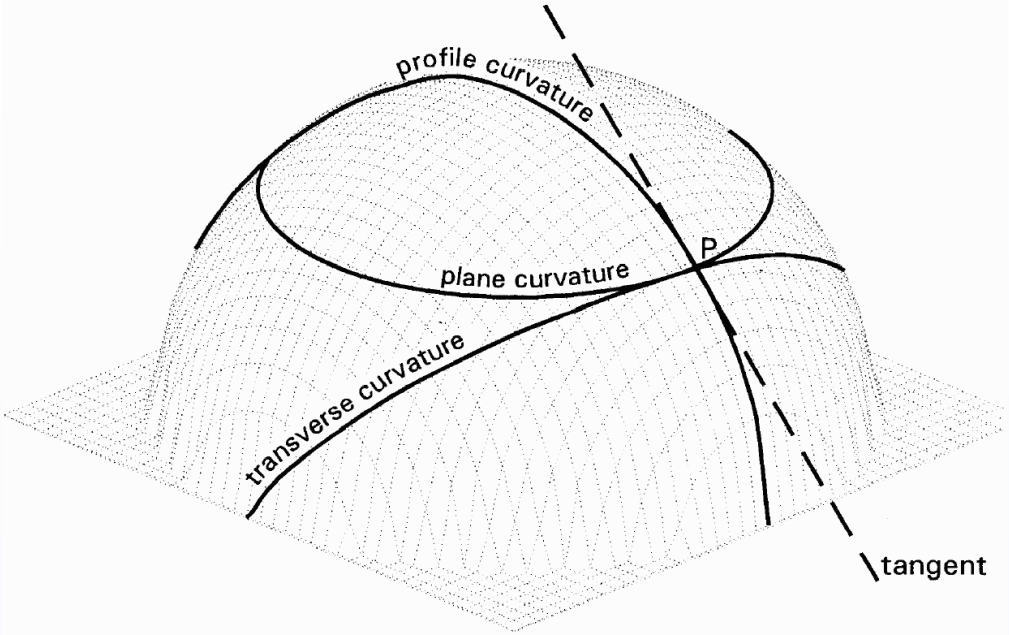



$$\text{aspect} = \arctan\left(\frac{Z_y}{-Z_x}\right)$$

$$= 180 - \arctan\left(\frac{Z_y}{Z_x}\right) + 90\left(\frac{Z_x}{|Z_x|}\right)$$

# Curvature

- Rate of change of slope
- Line made by intersection of plane with slope
- Types:
  - Profile
  - Plane (contour)
  - Tangential
  - Total: surface curvature

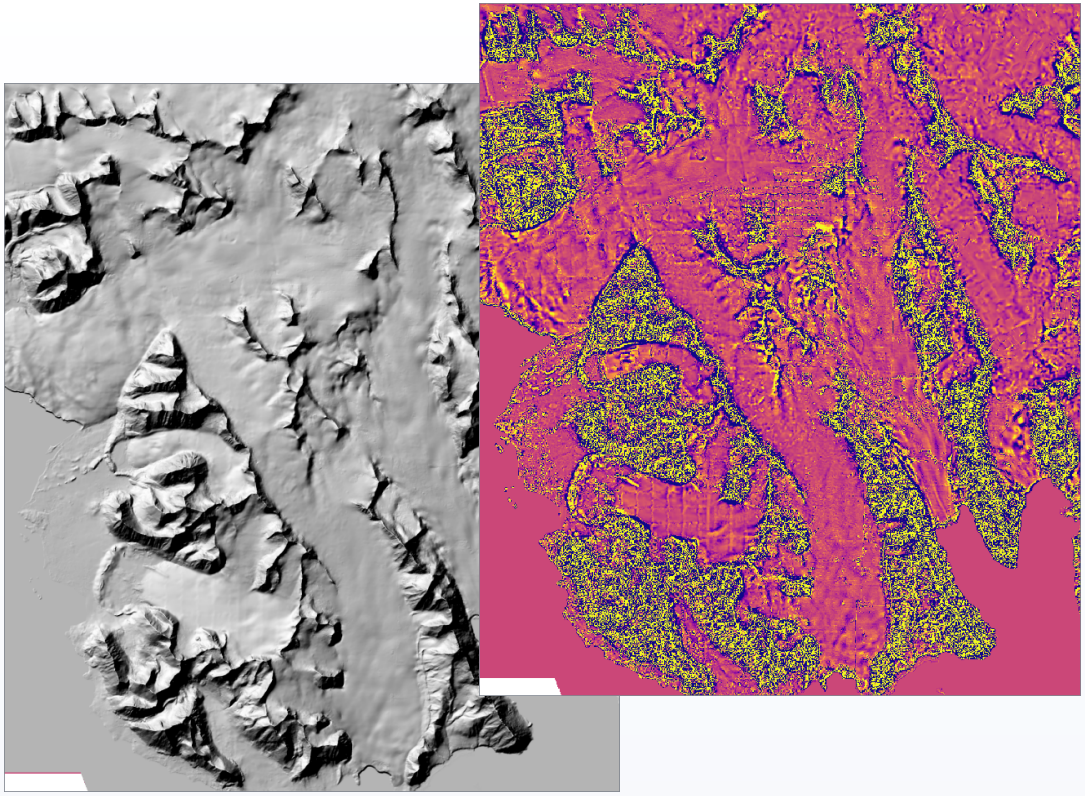


# Curvature

- Curvature is a second derivative
- Total curvature:

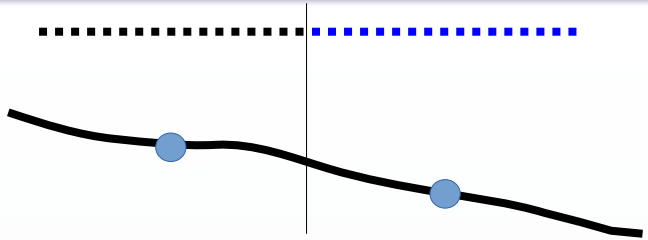
$$K = Z_{xx}^2 + 2Z_{xy}^2 + Z_{yy}^2$$

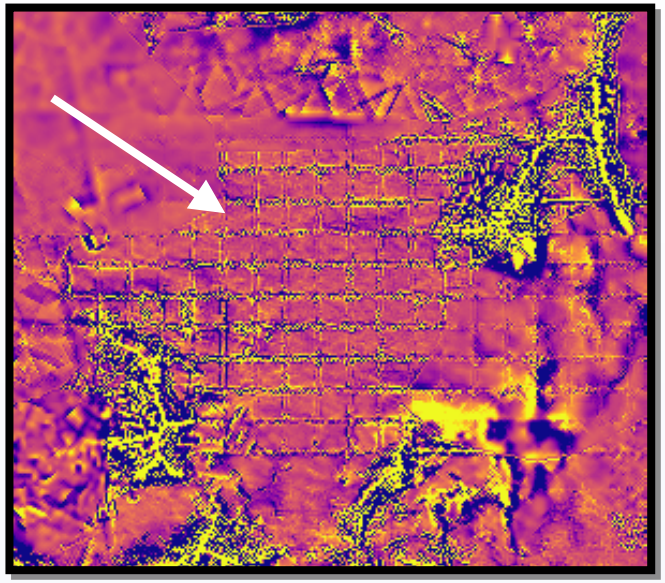
- Local differences are highlighted
  - Useful for finding errors in DEMs



# Interpolation

- Remember: elevation is continuous, represented as discrete points
- Some interpolation methods not suited for continuous data
  - e.g., Nearest Neighbor
- Can be seen in total curvature, hillshade





# Summary

- DEMs represent a (presumed) continuous surface
  - Be careful with interpolation!
- Derive parameters/attributes from DEMs to use for further analysis/study:
  - Slope, Aspect
  - Curvature
  - Hypsometry

# Additional resources

- Zevenbergen and Thorne, 1987 [ESPL]
- An overview of the Surface toolset [ESRI]