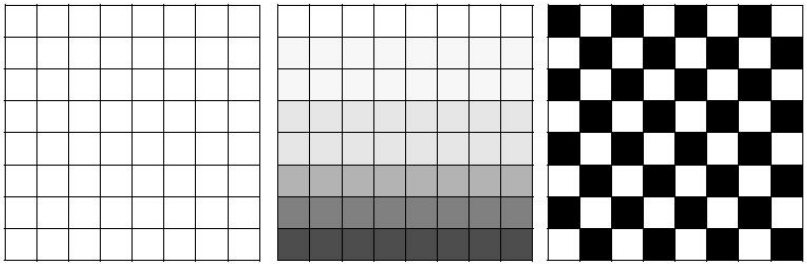
Derived Surfaces, Viewsheds, & Watersheds



zero spatial frequency *low spatial frequency* *high spatial frequency*

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Terrain Descriptors

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- Quantitative
  - Form of an individual terrain feature
    - Relief
    - Slope (gradient & aspect)
    - Wavelength
    - Curvature (profile & plane curvature)
    - Hillshade
  - Landscape roughness
    - Frequency spectrum (Fourier Transformation)
    - Fractal dimension
  - Landscape spatial autocorrelation
    - Covariance
    - Semivariogram
- Qualitative

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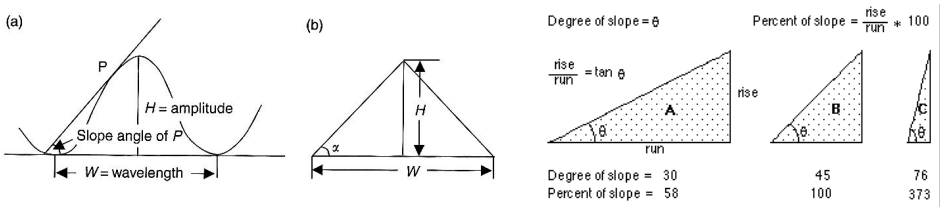
Terrain Roughness Vector

- Relief (elevation range)
- Wavelength
- Slope (gradient and aspect)



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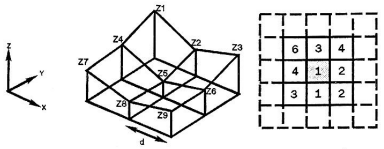
Curvature (Convexity)

- Surface curvature
- Profile curvature
- Plan (planform) curvature

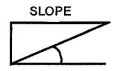
Calculating Elevation Derivatives of a DEM



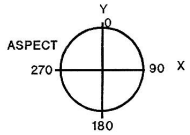
$A = [(Z1+Z3+Z7+Z9)/4 - (Z2+Z4+Z6+Z8)/2 + Z5]/d^4$
$B = [(Z1+Z3-Z7-Z9)/4 - (Z2-Z8)/2]/d^3$
$C = [(-Z1+Z3-Z7+Z9)/4 + (Z4-Z6)/2]/d^3$
$D = [(Z4+Z6)/2 - Z5]/d^2$
$E = [(Z2+Z8)/2 - Z5]/d^2$
$F = (-Z1+Z3+Z7-Z9)/4d^2$
$G = (-Z4+Z6)/2d$
$H = (Z2-Z8)/2d$
$I = Z5$

Undefined aspect (flat): -1
Curvature unit is 1/100 zunits

- Hilly area (moderate relief) -0.5 to 0.5
- Rugged mountains (extreme relief) -4 and 4



$SLOPE = SQRT(G^2 + H^2)$



$ASPECT = \arctan(-H/-G)$

ArcGIS:
Second-order finite difference algorithm (Zevenbergen & Thorne 1987)

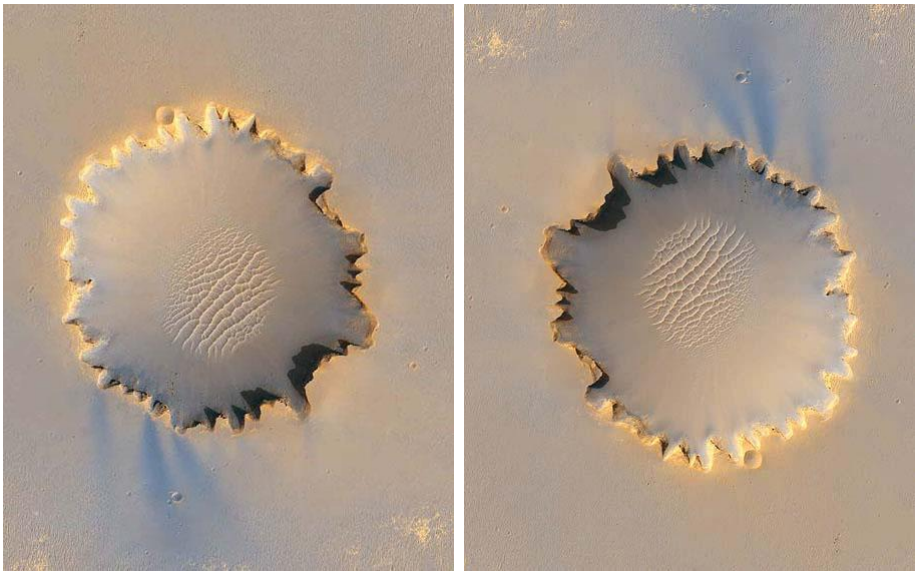
$PrC = 2(DG^2 + EH^2 + FGH)/(G^2 + H^2)$

$PlC = -2(DH^2 + EG^2 - FGH)/(G^2 + H^2)$

concave = positive
convex = negative

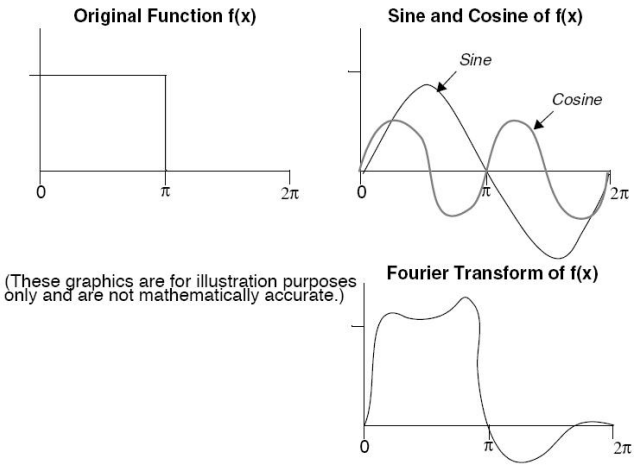
Hillshade

- Light source
  - Azimuth (0-360) default 315
  - Altitude (0-90) default 45
- Local illumination angle
  - Slope and aspect
  - 0 (shadow) ~ 255 (brightest)
- Shadow
  - Viewshed (0 in shadow)



Spectrum (Wavelet) Analysis & Fourier Transformation

Figure 6-30: One-Dimensional Fourier Analysis



(These graphics are for illustration purposes only and are not mathematically accurate.)

Sinusoids

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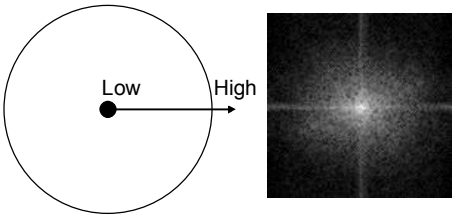
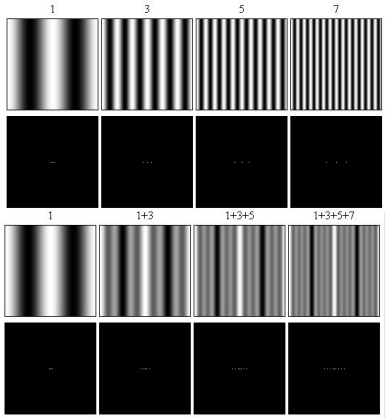
Image Domains

Spatial domain (2D images)
Frequency domain (Fourier Transformation)
Spectral domain (Feature space plots, scatterplots)





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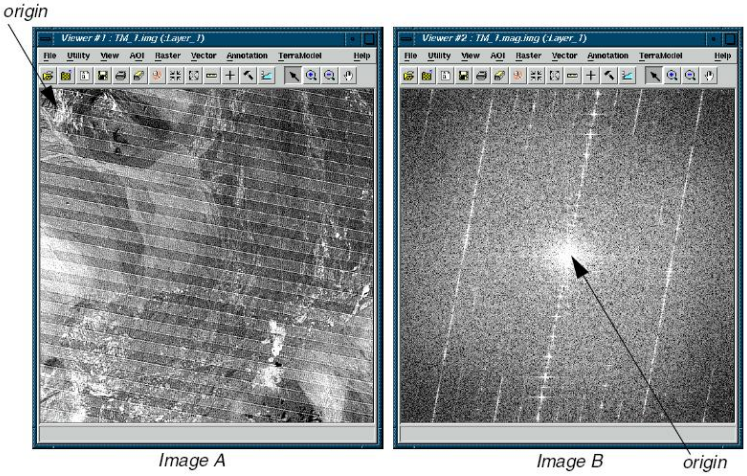


Fractal Dimension

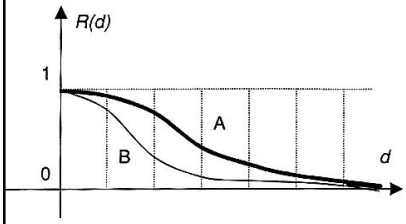
	Euclidean dimension	Effective dimension
Curve	1	1 ~ 2
Surface	2	2 ~ 3

Fractal Dimension and Complexity of Geometry

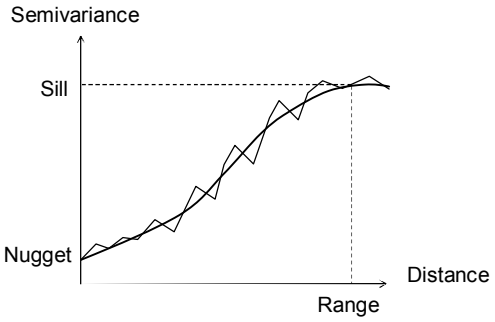
Curve	1: simple	2: complex
Surface	2: planar	3: rough

Spatial Autocorrelation

Covariance



Semivariance



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Other Quantitative Descriptors?

- Descriptive statistics
  - Mean
  - Standard Deviation
  - Range
- Texture

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Qualitative Descriptors

- Terrain classification
  - Terrain surface cover
  - Genesis of landforms
  - Physiography
  - Data-based

Quiz

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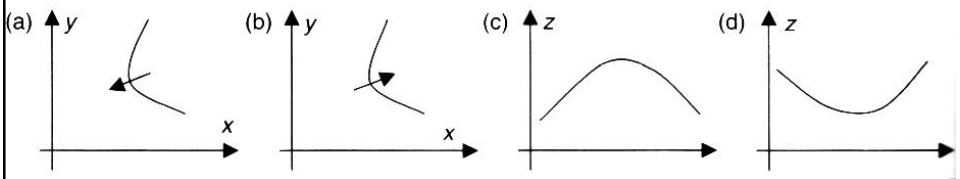
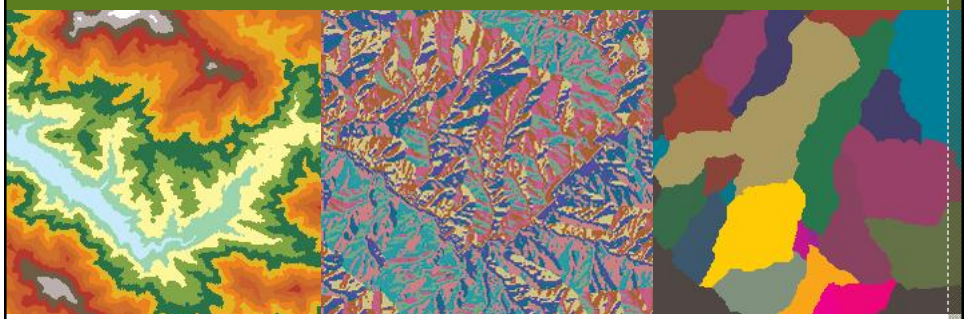
The following figures represent the horizontal and vertical profiles of a slope. Please match the correct curvature description with each figure.



1. Positive plan curvature
2. Positive profile curvature
3. Negative plan curvature
4. Negative profile curvature

Answer:
(a): 1
(b): 3
(c): 2
(d): 4

Viewsheds and Watersheds



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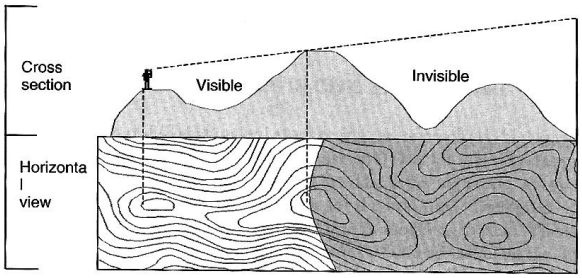
Visibility Analysis

- Intervisibility of line-of-sight
- Viewshed: point-to-area visibility



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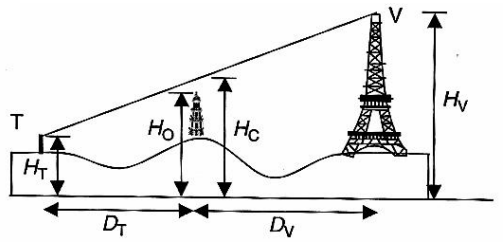
Line of Sight



$$h_C = \frac{D_T h_V + D_V h_T}{D_T + D_V}$$

$$D_{TO} = \frac{h_O}{h_V - h_O} \times D_{VO}$$

Considerations of Viewshed Analysis

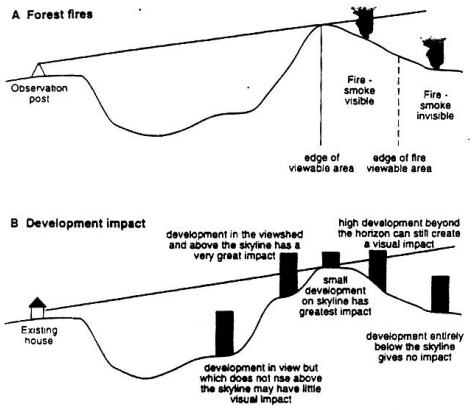
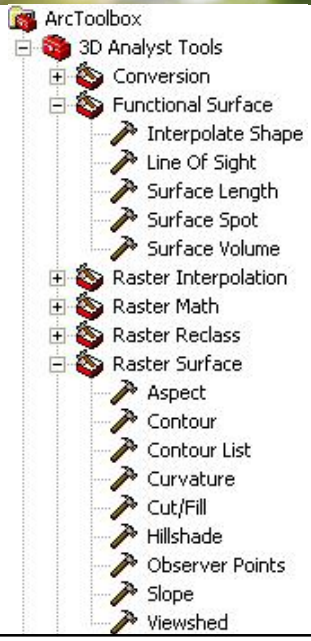


Figure 1. Examples of situations in which the binary viewshed will not yield useful results.

Figure 2. Just because a viewer at one location can see the ground surface at another location does not mean that a viewer at the second location could see the ground at the first.

Telecom site analysis:
Radio wave characteristics

ArcToolBox: 3D Analyst



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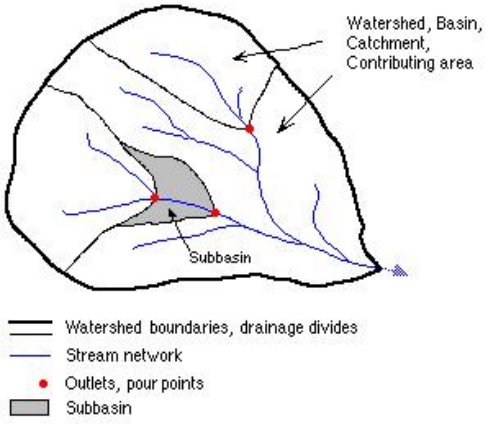
Hydrological Analysis of Terrain Data

Stream links



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Flow Direction

Single vs multi-flow directions

- D4, D8

(a)

6	7	8
5	0	1
4	3	2

(b)

64	128	1
32	0	2
16	8	4

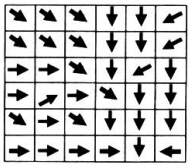
(c)

32	64	128
16	0	1
8	4	2

(a)

78	72	68	73	60	48
75	68	56	50	46	50
70	55	45	40	39	47
65	57	53	26	30	26
67	60	48	23	18	20
75	55	45	12	10	12

(b)



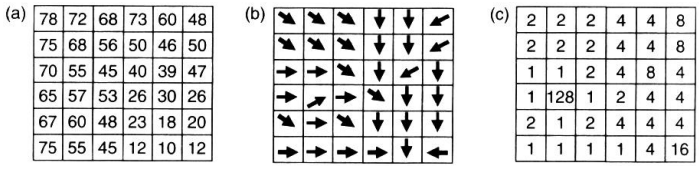
(c)

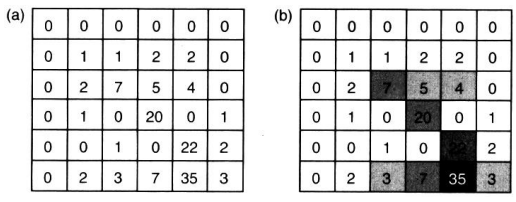
2	2	2	4	4	8
2	2	2	4	4	8
1	1	2	4	8	4
1	128	1	2	4	4
2	1	2	4	4	4
1	1	1	1	4	16

Sinks (depressions, pits, …)

- All neighboring cells are higher than the sink cell
- Two cells flow into each other
- Sinks have undefined flow directions and are assigned a value that is the sum of their possible directions.
- For example, if the steepest drop and, therefore, flow direction, are the same to both the right (1) and left (16), the value 17 would be assigned as the flow direction for that cell.
- A digital elevation model (DEM) that has been processed to remove all sinks is called a depressionless DEM.

Flow Accumulation





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Watershed Delineation Steps