Slope & Aspect

ASPECT AND SLOPE FACTORS

- The most important factor is the resolution of the DEM used for deriving slope and aspect ,The quality of the DEM also influences slope and aspect measures
- Local topography can also be a factor in estimating slope and aspect.
- Steeper slopes may create errors in slope estimates, but gentler slopes create errors in aspect estimates.
- Slope and aspect are basic elements for analyzing and visualizing landform characteristics.
- Slope and aspect are important in studies of watershed units, landscape units and other measures.
- Slope and aspect can also assist in solving problems in forest inventory estimates, soil erosion, habitat suitability, site analysis and others

Calculating slope

- Inclination of the land surface measured in degrees or percent
  - 3 x 3 cell filter
  - find best fit tilted plane that minimises squared difference in height for each cell
  - determine slope of centre (target) cell

$$z = a + bx + cy$$

10	9	8
8	8	7
7	6	5

$$Slope = b^2 + c^2$$

Calculating aspect

- Direction the land surface is facing measured in degrees or nominal classes (N, S, E, W, NE, SE, NW, SW, etc.)
  - use 3 x 3 filter and best fit tilted plane
  - determine aspect for target cell

10	9	8
8	8	7
7	6	5

$$Aspect = \tan^{-1} c / b$$

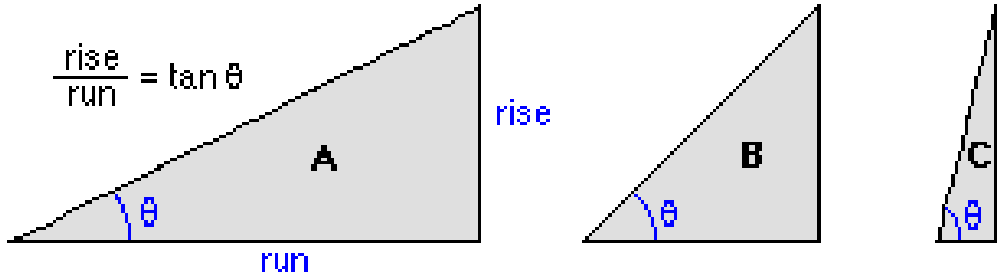
How Slope works

- For each cell, Slope calculates the maximum rate of change in value from that cell to its neighbors.
- Basically, the maximum change in elevation over the distance between the cell and its eight neighbors identifies the steepest downhill descent from the cell.
- Conceptually, the Slope function fits a plane to the z-values of a 3 x 3 cell neighborhood around the processing or center cell.
- The slope value of this plane is calculated using the average maximum technique. The direction the plane faces is the aspect for the processing cell.
- The lower the slope value, the flatter the terrain; the higher the slope value, the steeper the terrain

- The percent rise can be better understood if you consider it as the rise divided by the run, multiplied by 100. Consider triangle B below. When the angle is 45 degrees, the rise is equal to the run, and the percent rise is 100 percent. As the slope angle approaches vertical (90 degrees), as in triangle C, the percent rise begins to approach infinity.

Degree of slope = θ

Percent of slope = $\frac{\text{rise}}{\text{run}} * 100$



Degree of slope =	30	45	76
Percent of slope =	58	100	373

The Slope algorithm

- The rate of change (delta) of the surface in the horizontal (dz/dx) and vertical (dz/dy) directions from the center cell determines the slope. The basic algorithm used to calculate the slope is:
- Slope radians = ATAN (√ ([dz/dx]2 + [dz/dy]2))

Slope is commonly measured in degrees, which uses the algorithm:

- Slope degrees = ATAN (√ ([dz/dx]2 + [dz/dy]2)) * 57.29578

The slope algorithm can also be interpreted as:

- Slope degrees = ATAN (rise_run) * 57.29578

where:

- Rise run = √ ([dz/dx]2 + [dz/dy]2]

- The values of the center cell and its eight neighbors determine the horizontal and vertical deltas.
- The neighbors are identified as letters from 'a' to 'i', with 'e' representing the cell for which the aspect is being calculated.

a	b	c
d	e	f
g	h	i

- The rate of change in the x direction for cell 'e' is calculated with the algorithm:
- $[dz/dx] = ((c + 2f + i) - (a + 2d + g) / (8 * x\_cell\_size)$

The rate of change in the y direction for cell 'e' is calculated with the following algorithm:

- $[dz/dy] = ((g + 2h + i) - (a + 2b + c)) / (8 * y\_cell\_size)$

A Slope calculation example

- As an example, the slope value of the center cell of the moving window will be calculated.

a	b	c
d	e	f
g	h	i

50	45	50
30	30	30
8	10	10

- The cell size is 5 units. The default slope measure of degrees will be used.
-

  The rate of change in the x direction for the center cell 'e' is:
- [dz/dx] = ((c + 2f + i) – (a + 2d + g)) / (8 * x_cell_size)= ((50 + 60 + 10) – (50 + 60 + 8)) / (8 * 5)
- = (120 – 118) / 40 = 0.05
- The rate of change in the y direction for cell 'e' is:
- [dz/dy] = ((g + 2h + i) – (a + 2b + c)) / (8 * y_cell_size)= ((8 + 20 + 10) – (50 + 90 + 50)) / (8 * 5)
- = (38 – 190) / 40 = -3.8

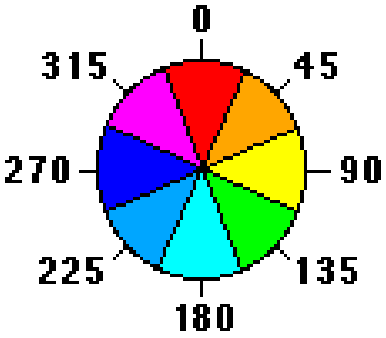
- Taking the rate of change in the x and y direction, the slope for the center cell 'e' is calculated using:

- rise_run = $\sqrt{}$ ([dz/dx]2 + [dz/dy]2)= $\sqrt{}$ ((0.05)2 + (–3.8)2]
- = $\sqrt{}$ [0.0025 + 14.44] = 3.80032

- slope_degrees = ATAN (rise_run) * 57.29578
- = ATAN (3.80032) * 57.29578
- = 1.31349 * 57.29578 = 75.2576

How Aspect works

- Aspect identifies the downslope direction of the maximum rate of change in value from each cell to its neighbors.
- Aspect can be thought of as the slope direction.
- The values of the output raster will be the compass direction of the aspect.



- Conceptually, the Aspect function fits a plane to the z-values of a 3 x 3 cell neighborhood around the processing or center cell.
- The direction the plane faces is the aspect for the processing cell.
- Flat areas in the input raster—areas where the slope is zero—are assigned an aspect of -1

The Aspect algorithm

- A moving 3 x 3 window visits each cell in the input raster and for each cell in the center of the window, an aspect value is calculated using an algorithm that incorporates the values of the cell's eight neighbors.
- The cells are identified as letters 'a' to 'i', with 'e' representing the cell for which the aspect is being calculated

a	b	c
d	e	f
g	h	i

- The rate of change in the x direction for cell 'e' is calculated with the following algorithm:
- $[dz/dx] = ((c + 2f + i) - (a + 2d + g)) / 8$
- The rate of change in the y direction for cell 'e' is calculated with the following algorithm:
- $[dz/dy] = ((g + 2h + i) - (a + 2b + c)) / 8$

Taking the rate of change in both the x and y direction for cell 'e', aspect is calculated using:

- $aspect = 57.29578 * atan2 ([dz/dy], -[dz/dx])$

- The aspect value is then converted to compass direction values (0–360 degrees), according to the following rule:
  - if aspect < 0 cell = 90.0 – aspect
  - else if aspect > 90.0
  - cell = 360.0 – aspect + 90.0
  - else
  - cell = 90.0 – aspect

An Aspect calculation example

- The rate of change in the x direction for the center cell 'e' is:
- [dz/dx] = ((c + 2f + i) – (a + 2d + g)) / 8= ((85 + 170 + 84)) – (101 + 202 + 101)) / 8
- = –8.125
-

  The rate of change in the y direction for cell 'e' is:
- [dz/dy] = ((g + 2h + i) – (a + 2b + c)) / 8= ((101 + 182 + 84) – (101 + 184 + 85)) / 8 = –0.375
- The aspect is calculated as:
- aspect = 57.29578 * atan2 ([dz/dy], –[dz/dx])= 57.29578 * atan2 (–0.375, 8.125)
- = –2.64

a	b	c
d	e	f
g	h	i

101	92	85
101	92	85
101	91	84

- Since the calculated value is less than zero, the final rule will be applied as:
- Cell = 90.0 – aspect= 90 – (–2.64)
- = 90 + 2.64
- = 92.64

- The value of 92.64 for the center cell 'e' indicates its aspect is in the easterly direction